

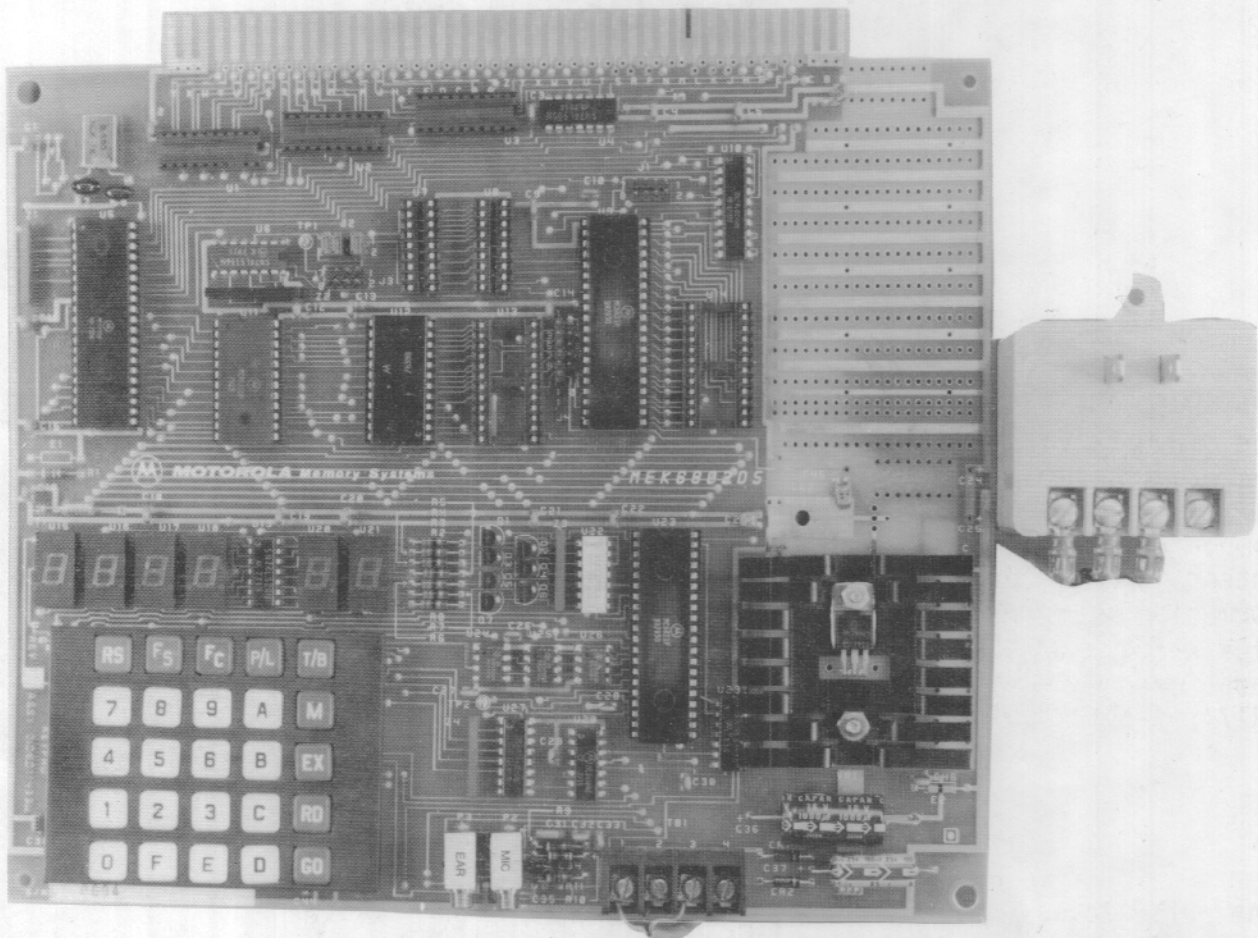


MOTOROLA INC.

MEK6802D5
MICROCOMPUTER
EVALUATION BOARD
USER'S MANUAL

Memory Systems

MEK6802D5(D2)



MEK6802D5 MICROCOMPUTER EVALUATION BOARD

MEK6802D5

MICROCOMPUTER EVALUATION BOARD USER'S MANUAL

PREFACE

The MEK6802D5 Microcomputer Evaluation Board provides the necessary hardware and firmware for a computer system based on the Motorola MC6802 Microprocessor. The system forms an evaluation tool to facilitate the application of Motorola microprocessors and associated components. The system is supplied with all the components required to operate, including a 115 Vac plug-in transformer and integral power supply and can be used in various configurations. With the information supplied in this manual, the user can prototype dedicated systems plus write and evaluate software programs in machine language. Provisions are made for extensive system expansion using a video terminal or keyboard and CRT/TV display unit.

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MEK6802D5 SPECIFICATIONS

System Components:	MC6802 Microprocessor D5BUG Firmware (2K) Six 7-segment displays 25-key scanned keypad 300 Baud cassette interface Uncommitted user PIA Wire Wrap area On-board power supply
Supply Voltage:	120 Vac 60 Hz to external transformer, 18 Vac input to board, +5 Vdc regulated output on board.
Operating Temperature:	0 °C to 55 °C (32 °F to 131 °F)
Relative Humidity:	To 80% without condensation
Dimensions:	A two-sided printed circuit board measuring 9.75 in (247.65 mm) wide by 8.75 in (222.25 mm) high by 0.062 in (1.57 mm) thick.
Options/Expansion:	Two (2) MCM2114 1K x 4 RAMs One (1) ROM Bus buffers MEK6800AB Motherboard MEK68R2 CRT display board ASCII Keyboard CRT/TV Monitor MEK68MM RAM board MEK68RR RAM/ROM board MEK68IO Input/Output Interface MEK68EP EPROM Programmer
Software Features:	Memory Change/Display Advance to next ADDR Back-up to previous ADDR Calculate offsets Register Change/Display Breakpoint Editor Cassette punch/load/verify Trace single instruction Go To/Continue user program User function capability Escape from all functions Save user registers

CHAPTER 1

GENERAL INFORMATION

1.1 Description

The MEK6802D5 Microcomputer Evaluation Board is a basic, low-cost system to evaluate the capability of the MC6800 Microcomputer Family of Components. It is useful as a tool to learn programming techniques, and to develop custom applications of microprocessors.

The system consists of an MC6802 microprocessor, D5BUG firmware in an MC68A316E ROM, (6) 7segment multiplexed displays, a 25-key scanned keypad, 300 Baud K.C. standard cassette interface and an on-board power supply capable of driving the minimum system.

A wire wrap area and an uncommitted user PIA are provided to allow the user to create desired options. In addition, provisions are made to add (2) MCM2114 1K x 4 RAMs, a 24-pin ROM or EPROM, and Bus buffers to an 86-pin connector.

All components, including the AC transformer required for the minimum system are supplied with the MEK6802D5.

The functions of the basic and optional components of the system are described in the following sections.

1.2 Components

1.2.1 MC6802 - MPU (U5)

The microprocessor generates the system clock, executes the programs residing in D5BUG, and also executes user programs. There are 128 bytes of RAM (reserved for the user in the D5) included in the MC6802 (addresses \$0000 to \$007F).

1.2.2 MC68A316E - D5BUG (U12)

This factory programmed ROM (Read Only Memory), also known as a Monitor, contains the operating system firmware programs which control the D5 system.

1.2.3 MC6821 - PIA (U23)

This PIA (Peripheral Interface Adapter) is the system PIA and interfaces the keypad and display to the MPU. This unit can transmit data (in

parallel form) in either direction and provides a flow path for data in or out of the system. It also interfaces the cassette interface circuitry and trace-one instruction timer to the MPU (U5).

1.2.4 MC6821 - PIA (U9)

This PIA interfaces the D5 to external devices or systems for the user to use in producing custom designs. It provides two 8-bit bi-directional data ports and four control lines connected to a 24-pin Dip socket located adjacent to U9.

1.2.5 MC6810 - Static RAM (U11)

This is a static RAM (Random Access Memory) used as a scratch pad for the MPU (U5). It provides 128 bytes of Flag, Data, and Stack area for the D5BUG operating system (24 bytes are allowed for use as a user's stack area).

1.2.6 LED Display

The display system consists of LEDs, U15, U16, U17, U18, U20, U21; anode drivers Q1 through Q7; and cathode drivers U24 through U26. The system PIA (U23) uses seven lines to drive the anode drivers and six lines to drive the cathode drivers.

1.2.7 Keyboard

Depressing a key generates an interrupt to the processor. The system firmware causes the processor to search for the key closure and act upon it.

1.3 Optional Devices

1.3.1 MC2114 RAM Memories (U7, U8)

There are two 18 pin sockets for installing MCM2114 (1K x 4 bit) static RAM memories.

1.3.2 Bus Drivers (U1, U2, U3, U10)

These units interface the processor to an 86 pin connector to expand the MEK6802D5 system.

CHAPTER 2

INSTALLATION

2.1 Preparation For Use

2.1.1 Handling

CAUTION

Turn power off before removing or installing components

SPECIAL HANDLING REQUIRED

Store board in special conductive bag. Do not touch circuitry while handling. Static discharge may damage components.

Generally, it is required that the board and repairing personnel all be at the same (ground) potential. If the unit is on a bench or is not installed, a common ground connection between installing and/or repairing personnel and the unit should be made.

2.2 Use

Place the D5 board on its stand offs or otherwise insulated from a bench or table top and plug the transformer into a wall outlet of the correct AC voltage. Refer to the operation section of this manual for more information.

2.3 Precautions

Because MOS devices have extremely high input resistance, they are susceptible to damage when exposed to high static electrical charges.

To avoid possible damage to the devices during handling, testing, or actual operation, use the following procedures:

- a) The leads of devices should be in contact with a conductive material, except when being tested or in actual operation, to avoid build-up of static charge.

2.3 Precautions (cont'd)

- b) Soldering-iron tips, metal parts of fixtures and tools, and handling facilities should be grounded.
- c) Devices should not be inserted into or removed from circuits with the power on because transient voltages may cause permanent damage.
- d) Signals should not be applied to the inputs while the device power supply is off.
- e) All unused input leads must be connected to either V_{SS} (ground) or V_{DD} (device supply), whichever is appropriate for the logic circuit involved.

2.3.1 Handling of Unmounted Chips

In handling of unmounted chips, care should be taken to avoid differences in voltage potential. A conductive carrier, or a carrier having a conductive overlay should be used.

Some CMOS chips use a double diode plus resistor input protection circuit. This input protection circuit will clamp the input voltage to the chip to within the V_{DD} and V_{SS} supply voltages. This will protect the CMOS chip from over-voltages of 100 volts for 0.1 millisecond. The static charges encountered in normal handling may be as high as 10,000 volts.

2.4 Pin Assignments

Refer to Table 2.1 for the Bus Pinout Assignments for the MEK6802D5.

2.5 System Bus Signal Description

System Bus Signals:

- (1) 16 Address lines (A_0 - A_{15}) - For selection of one byte or location from 64K bytes or locations.
- (2) 8 Data lines (D_0 - D_7) - Bidirectional lines that carry data information.
- (3) 9 Control lines:
 - (a) E - ENABLE. This signal is the system clock. A standard 3.579545 MHz crystal is used by the processor to generate the 894.8 KHz system clock.

TABLE 2.1. SYSTEM BUS PINOUTS

Pin Number	Description	Pin Number	Description
1	+5 VDC	A	+5 VDC
2	+5 VDC	B	+5 VDC
3	+5 VDC	C	+5 VDC
4	<u>HALT</u>	D	<u>IRQ</u>
5	<u>RESET</u>	E	<u>NMI</u>
6	R/ <u>W</u>	F	VMA
7		H	
8	+12 V GND (ref)	J	E (Ø2)
9	+12 V GND (ref)	K	+12 V GND (ref)
10		L	
11	-12 V (ref)	M	-12 V (ref)
12		N	
13		P	BA
14		R	MR
15		S	
16	+12 V (ref)	T	+12 V (ref)
17		U	
18		V	
19		W	
20		X	
21		Y	
22		Z	
23		<u>A</u>	
24		<u>B</u>	
25	-5 V (ref)	<u>C</u>	
26		<u>D</u>	
27		<u>E</u>	
28		<u>F</u>	
29	D1	<u>H</u>	D3
30	D5	<u>J</u>	D7
31	DØ	<u>K</u>	D2
32	D4	<u>L</u>	D6
33	A15	<u>M</u>	A14
34	A12	<u>N</u>	A13
35	A11	<u>P</u>	A10
36	A8	<u>R</u>	A9
37	A7	<u>S</u>	A6
38	A4	<u>T</u>	A5
39	A3	<u>U</u>	A2
40	AØ	<u>V</u>	A1
41	GND	<u>W</u>	GND
42	GND	<u>X</u>	GND
43	GND	<u>Y</u>	GND

2.5 System Bus Signal Description (cont'd)

(3) 9 Control lines (cont'd)

- (b) R/\overline{W} - Read/Write. This is the read-write control line. Its logic state determines the direction of data (into or out of) a selected chip. When high, the data direction is toward the processor (read), and when low, the data direction is away from the processor (write).
- (c) VMA - Valid Memory Address. When low this signal indicates that the address on the bus is invalid.
- (d) MR - Memory Ready. This control signal can cause the E signal to be stretched. When MR is high, E will be in normal operation. When MR is low, E may be stretched an integral multiple of half periods, thus allowing interface to slow devices.
- (e) \overline{RESET} . This line is used to reset and start the MPU.
- (f) BA - Bus Available. When this signal is active, the MC6802 is stopped and the address bus is available for external devices (but not tri-state).
- (g) \overline{HALT} . When this signal is active, all activity of the MC6802 will be halted.
- (h) \overline{IRQ} - Interrupt Request. This signal requests than an interrupt sequence be generated within the MC6802. If the interrupt mask bit in the condition code register is set, the \overline{IRQ} input is disabled.
- (i) \overline{NMI} - Non-Maskable Interrupt. This signal is similar to \overline{IRQ} except that the interrupt mask bit in the condition code register has no effect on \overline{NMI} .

2.6 System Interfaces

2.6.1 Power

For the minimum system, an on-board power supply is provided which is driven by an 18 Vac center tapped transformer. Refer to Figure 2.1 (see page 2-5) in connecting the 18 Vac transformer.

If it is necessary to use an external supply for more power, just remove jumper E2 and connect the external supply as shown in Figure 2.2 (see page 2-5).

2.6.1 Power (cont'd)

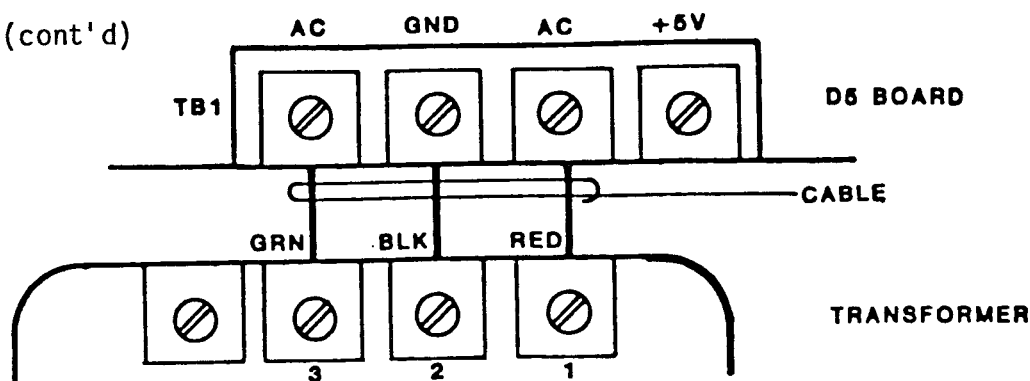


FIGURE 2.1. 18 VAC TRANSFORMER CONNECTION

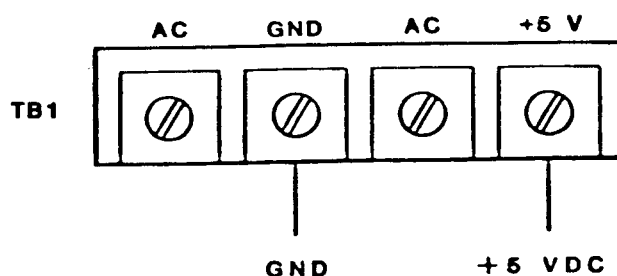


FIGURE 2.2. EXTERNAL SUPPLY CONNECTION

2.6.2 User PIA

A 40-pin socket has been provided to allow an additional uncommitted MC6821P in the D5. The PIA (U9) is supplied with the kit and the interface signals are available at the 24-pin socket (U14).

TABLE 2.2. USER PIA CONNECTOR PINOUTS

Pin Number	Description	Pin Number	Description
1	PA6	13	GND
2	PA7	14	N.C.
3	PB0	15	PA5
4	PB1	16	PA4
5	PB2	17	PA3
6	PB3	18	PA2
7	PB4	19	PA1
8	PB5	20	PA0
9	PB6	21	CA2
10	PB7	22	CA1
11	CB1	23	N.C.
12	CB2	24	+5 V

2.6.2 User PIA (cont'd)

The $\overline{\text{IRQA}}$ and $\overline{\text{IRQB}}$ outputs of the user PIA may be connected to either $\overline{\text{NMI}}$ or $\overline{\text{IRQ}}$. Refer to the following figure while making connections.

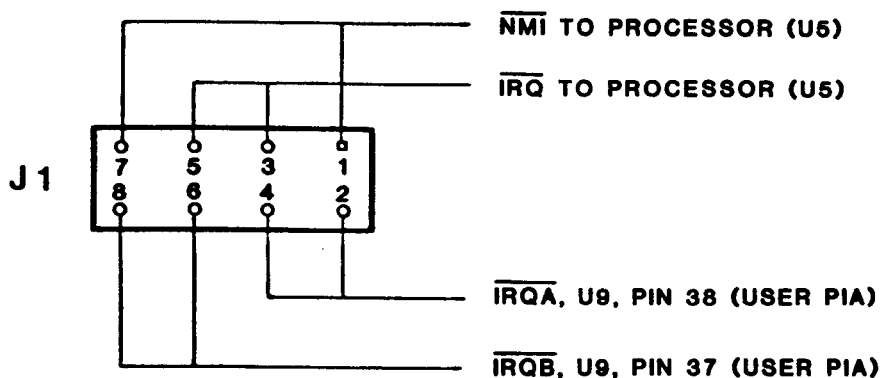


FIGURE 2.3. USER PIA INTERRUPT CONNECTIONS

The User PIA is decoded to appear at \$E480.

PORT A	-----	\$E480
DATA DIRECTION A	-----	\$E480
CONTROL REG. A	-----	\$E481
PORT B	-----	\$E482
DATA DIRECTION B	-----	\$E482
CONTROL REG. B	-----	\$E483

2.6.3 Cassette

A 300 Baud Kansas City standard compatible cassette interface is provided for program storage. Most low-cost cassette recorders are compatible with the D5. The output from the cassette is connected to the "EAR" input at P3 of the D5. Generally the higher the cassette output level the better, but the D5 may accept as low as 2.0 Vpp.

To record programs connect the "MIC" output from P2 of the D5 to the "MIC" input to the cassette recorder. The D5 sends a 50 mVpp signal of 1200 Hz and 2400 Hz for zeroes and ones respectively.

2.7 Options

Several options are available for the user through installation or removal of various jumpers or components. In general, addition of options will require additional power which the on-board power supply may or may not be capable of supplying. The limiting factor in the on-board supply is the 7805 regulator heat dissipation characteristics. Some added power capability can be achieved by going to a TO-3 type regulator which can dissipate more heat. If the on-board regulator cannot supply enough power for the added options, then E2 may be removed to disconnect this regulator from the system allowing power to be supplied at the edge connector, or through the four (4) terminal barrier block TB1.

2.7.1 User RAM

Provisions have been made to allow addition of 1K x 8 of User RAM. This RAM is decoded to appear at addresses \$E000 - \$E3FF. To add this option install (2) MCM2114 1K x 4 RAMs at U7 and U8.

2.7.2 User ROM

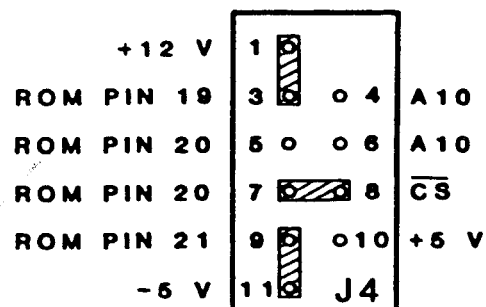
A 24-pin socket has been provided to allow the user to add an additional ROM with its own firmware. Decoding is provided to allow this ROM to appear at either of two areas in the memory map, \$E800 to \$EFFF or \$F800-\$FFFF. If the user wishes the ROM to contain the system restart and interrupt vectors, select the ROM at \$F800-\$FFFF and disable the monitor ROM from mirroring there. The user then has full access to all operating system routines but has priority during restart and interrupts. In addition to selecting where this ROM will appear, the user can connect the socket to accept various ROM or EPROM types. The following table outlines the proper connections for the most common EPROM types.

TABLE 2.3. EPROM CONNECTIONS

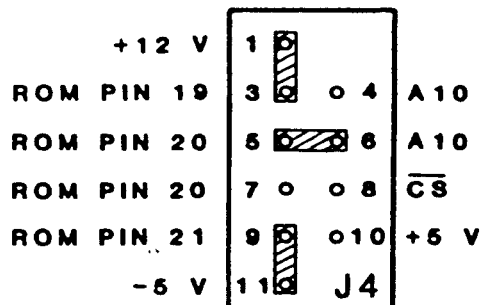
Types	Organization	Pin 21	Pin 20	Pin 19	Pin 18
MCM2708	1K x 8	-5 V	\overline{CS}	+12 V	GND
TMS2716	2K x 8	-5 V	A10	+12 V	\overline{CS}
MCM2716	2K x 8	+5 V	\overline{CS}	A10	GND

Refer to the following figures for configuring the ROM sockets as required. Figure 6.1, page 6-4 shows the location of these sockets.

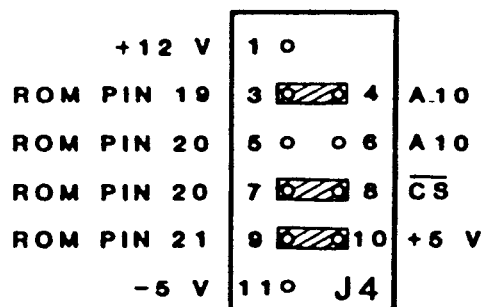
2.7.2 User ROM (cont'd)



a) Jumpers for 1K x 8, 3-supply EPROM.



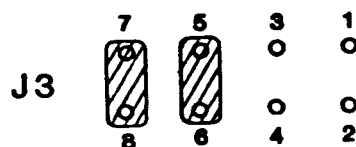
b) Jumpers for 2K x 8, 3-supply EPROM.



c) Jumpers for 2K x 8 single supply EPROM.

FIGURE 2.4. CONFIGURING THE ROM SOCKET

2.7.2 User ROM (cont'd)



a) Option 1, select at \$E800 to \$EFFF.



b) Option 2, select at \$F800 to \$FFFF.

FIGURE 2.5. USER ROM OPTIONS

To use option 2 the system monitor mirror must be disabled by removing the jumper between pins 1-2 of J2.

2.8 Bus Expansion

To expand the D5 through the 86-pin connector, install (2) 74LS244 octal buffers at U1 and U2 and (1) 74LS245 octal bidirectional buffer at U3. Also install a jumper at E1 to disable the MC6802's internal RAM.

CHAPTER 3

OPERATION

3.1 Common Terms and Notations

Microprocessors are digital devices which understand 1 (ones) and 0 (zeroes). In the MC6802 there is a 16-bit address bus and an 8-bit data bus which communicate digitally (with binary 1's and 0's). It becomes cumbersome to specify 16-bit addresses and 8-bit data in binary 1's and 0's so a shorthand code called hexadecimal is used. Each hexadecimal digit (hex digit for short) represents (4) binary bits.

In order to distinguish hex digits from ordinary decimal numbers, precede the hex number with a dollar sign (\$). Sometimes it is very obvious that a number is a hex number and the "\$" symbol may be left off as in program listings. In a binary number, the leftmost bit is called the Most Significant Bit (MSB) and the rightmost bit is called the Least Significant Bit (LSB).

Any group of 8-bits is called a "byte" and a group of 4-bits may be called a "nibble". A "word" is a misleading term because many think it means 8-bits, but "word" really refers to the size of the data word.

In most microprocessors the data bus just happens to be 8-bits wide but there are exceptions such as the MC68000 which has a 16-bit "word" size.

Binary Number	Hex Representation
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Note: From 10 through 15 the letters A through F are used for a single symbol to represent the 4-bit binary number.

3.1 Common Terms and Notations (cont'd)

Since 7-segment displays are used on the D5, the hex values A through F are difficult to display. The letters B and D become lower case letters.

3.2 Display Indications

Step-by-step examples will show the resulting display. Notice there are 6 displays. In the examples a small letter x indicates "don't care"; that is it may not be possible to predict the actual value which will appear but it indicates that the display will not be dark.

3.3 Keypad Entries and Displays

Located at the end of this chapter are detailed examples which will help explain this section.

3.3.1 RESET

To reset the entire system, depress the "RS" button and the resulting display will be a dash in the left hand position.

3.3.2 ESCAPE

Normally it is possible to abort a user program by depressing the "EX" key; however, since this is dependent upon proper set-up of the keypad PIA, it is possible for the user's program to disable the ESCAPE function.

Assuming a user program and the ESCAPE function active at the time the "EX" key is depressed, the resulting display would reflect the current user Program Counter status and the system would be in the register display editor.

If the system was within the DEBUG operating system when "EX" was depressed the resulting display would be a dash in the left hand position.

3.3.3 Miscellaneous

While entering numeric information, the first digit entry will clear the entire register location being modified and the new digit will be rotated into the least significant 4 bits of the register. Subsequent entries will be shifted in from the right and there is no limit to the number of digits which may be entered. When the next command key is depressed, the value being displayed is the value which will be used.

3.3.3 Miscellaneous (cont'd)

When trying to GO to a user program, a check is performed to see that the user's system stack can support the process of exiting to the program. The method used to transfer control to the user program requires that the user's register contents be put on the system stack and, if no RAM exists at the "S" stack pointer location, then control cannot be passed to the program. The display will be -SP- ??.

3.3.4 Memory Display/Change

To display or change the contents of a memory location, first enter the hexadecimal address to be changed. Leading zeroes are not required and digits may be entered until the display is correct. When this address has been entered, depress the "M" key.

The first four display digits show the address of the memory location being operated on. The fifth and sixth displays show the actual contents of the displayed address and if they do not agree with the data entered, it is an indication that the location is not properly accepting data.

To advance to the next higher memory location, depress "GO" and to back-up to the next previous location, depress the "M" key.

3.3.5 Offset Calculation

To calculate a relative offset, depress "FS" from the memory display change editor. The memory location being displayed at the time the "FS" key was depressed is assumed to be the location of the offset byte. The display at this point will be an A in the right most position,



prompting an entry of the destination address. After this address has been entered, depress "GO". The offset will be calculated and checked to see if it is within the range of an 8-bit offset. The resulting display will be two numbers in the right most two displays or the letters BAD indicating the offset was out of range. The numbers are an 8-bit offset value.

Note this offset on the listing before continuing.

Depress "GO". The calculated offset is stored and control returned to the memory display/change editor. The memory location being displayed will be that immediately following the offset which was just stored.

3.3.5 Offset Calculation (cont'd)

If, for some reason, the calculated value should not be stored prior to continuing, depress the "FC" key which will return control to the memory display/change routine. The displayed memory location will be the same one from which the offset calculation routine was called.

If the calculation was "BAD" depressing "M" will return to the memory change editor.

3.3.6 Register Display/Alter

To get to register display, begin at the prompt point and depress "RD". The first register displayed will be the user's program counter.

3.3.7 Summary of Register Display Formats

pc	pc	pc	pc
		a	a
		b	b
x	x	x	x
sp	sp	sp	sp
		c	c

P	C
	A
	b
I	d
S	P
C	C

User program counter

User A - register

User B - register

User X index register

User stack pointer

User condition codes

To advance to the next sequential register depress the "GO" key and to back up to the next previous register depress the "M" key. The registers "wrap-around" so depressing "GO" while displaying CC, the next display will be PC.

To change the contents of a psuedo register, just step to that display and enter the desired value.

3.3.8 Trace Single Step

To trace a single MC6802 instruction, just depress "T/B" from within the register display editor. After executing a single user instruction, the operating system will regain control in the register display editor and all registers will reflect the action of the executed instruction. Depress "T/B" as many times as desired to execute that many instructions.

3.3.9 Go To User Program

To Go to a user program, start at the prompt point (a dash in the left most display). Enter the address desired and then depress "GO".

3.3.10 Continue

This is like GO to user program except instead of specifying the GO address, it is assumed to be the current value at the user program counter pseudo register. To invoke this function, depress "GO" from the "-" prompt point. It should not be necessary to enter any numbers prior to "GO" to invoke the "CONTINUE" function.

3.3.11 Breakpoints

To enter the breakpoint editor, depress "FS" then "T/B" from the prompt point.

To get out of the breakpoint editor, depress the "EX" key. To advance to another breakpoint specification, depress "GO". The advance function wraps around so successive presses of "GO" will eventually display all breakpoints. Up to 5 breakpoints may be active at any time.

To de-activate an existing breakpoint, advance to where it is being displayed and depress "FC". The last digit of the display (# of breakpoints) will decrement and another breakpoint will be displayed. To remove all breakpoints, depress "FC" as many times as needed until the "# of breakpoints" digit is zero.

To install a new breakpoint, enter its proposed hexadecimal address, then depress "FS". Breakpoints will only be installed where there is a RAM. If the "# of breakpoints" digit does not change, it is an indication that the breakpoint could not be installed either because five breakpoints already exist or because the breakpoint code (\$3F) could not be stored at the proposed address.

3.3.12 Punch

To punch a cassette tape, begin from the prompt (-) point. Depress "P/L" and the display will be 0000 bb, prompting for a beginning address.

For example, depress 1, 2, 3. The display will be 0123 bb.

Depress GO to enter this address. The display will now be 0000 EE, as a prompt to enter the last address of the data to be punched.

For example, depress 4, 5, 6, 7. The display will be 4567 EE.

3.3.12 Punch (cont'd)

Turn on the tape recorder in the RECORD mode and depress GO. A 30 second leader of \$FF characters will precede the data file.

When the punch process is complete, the prompt (-) returns and the D5 board is ready for the next command.

3.3.13 Load/Verify

The load command is "FS" then "P/L" while the verify command is "FS" - "RD".

When the load or verify is completed without errors, the prompt returns and the D5 is ready for the next command.

If an error occurred during load or verify, the message "Fail ??" appears on the display. The user may escape at this point and enter register display to find the error location. The address in error is indicated by the value in the X-register. Also the data in the A-register is the last byte read from the tape.

3.3.14 User Functions

User functions may be performed by use of the function set key and the user function pointer (FNCPNT).

User functions are invoked by typing "FS" and a hex digit.

User functions are set up by providing a table of addresses of user supplied functions, and by storing the address of the table at FNCPNT

Up to 16 functions may be added to the functions already on the D5.

Display and Programming Examples

These examples are given to illustrate programming techniques and applications using the MEK6802D5.

Example to display 'USE d5'

1. Determine the necessary 7-segment display codes required for the letters and numbers to be displayed. This information is found in the detailed description of the "PUT" routine in Chapter 7.

Symbol		Binary		Hex
U	=	0011 1110	=	\$3E
S	=	0110 1101	=	\$6D
E	=	0111 1001	=	\$79
space	=	0000 0000	=	\$00
d	=	0101 1110	=	\$5E
5	=	0110 1101	=	\$6D

2. Each symbol is listed with its binary equivalent and hex code keypad entry.
3. The program listing entries are explained in the D5BUG listing (Chapter 7). The complete program listing for this example is as follows (next page):

USED5

```

0001                      NAM      USED5
0002                      OPT      LLEN=80,CREF
0003A 0000                ORG      $0
0004                      * D5BUG ROUTINE
0005                      E41D  A  DISBUF EQU    $E41D
0006                      F0A2  A  DIDDLE EQU    $F0A2
0007                      E419  A  MNPTR EQU    $E419
0008                      F0BB  A  PUT   EQU    $F0BB
0009                      *
0010                      *
0011A 0000 86 3E      A  BEG      LDAA    #$3E      "U"
0012A 0002 B7 E41D    A          STAA    DISBUF    STORE TO FIRST DISPLAY
0013A 0005 86 6D      A          LDAA    #$6D      "S"
0014A 0007 B7 E41E    A          STAA    DISBUF+1
0015A 000A 86 79      A          LDAA    #$79      "E"
0016A 000C B7 E41F    A          STAA    DISBUF+2
0017A 000F 86 00      A          LDAA    #$00      BLANK
0018A 0011 B7 E420    A          STAA    DISBUF+3
0019A 0014 86 5E      A          LDAA    #$5E      "D"
0020A 0016 B7 E421    A          STAA    DISBUF+4
0021A 0019 86 6D      A          LDAA    #$6D      "5"
0022A 001B B7 E422    A          STAA    DISBUF+5 STORE TO LAST DISPLAY
0023A 001E CE F0A2    A          LDX     #DIDDLE ADDR OF DIDDLE ROUTINE
0024A 0021 FF E419    A          STX     MNPTR  ESTABLISH AS ACTIVE SUB OF "PUT"
0025A 0024 7E F0BB    A          JMP     PUT   CALL DISPLAY ROUTINE
0026                      END

```

ERRORS 00000--00000

```

0000 BEG      0011*
F0A2 DIDDLE  0006* 0023
E41D DISBUF  0005* 0012 0014 0016 0018 0020 0022
E419 MNPTR   0007* 0024
F0BB PUT     0008* 0025

```

After entering this program into memory using Memory Change, press "0" and "GO" to begin execution.

Display and Programming Examples (cont'd)

Example to display 'HELP --'

1. Determine the 7-segment codes required, as in the previous example.

Symbol	Binary	Hex
H =	0111 0110	= \$76
E =	0111 1001	= \$79
L =	0011 1000	= \$38
P =	0111 0011	= \$73
- =	0100 0000	= \$40
- =	0100 0000	= \$40

2. Each symbol is listed with its binary and hex codes equivalent.
3. The program listing entries are explained in the D5BUG listing (Chapter 7). The complete program listing for this example is as follows (next page):

HELP

```

0001          NAM      HELP
0002          OPT      LLEN=80,CREF
0003A 0000     ORG      $0
0004          * D5BUG ROUTINES
0005          FOA2  A DIDDLE EQU    $FOA2
0006          E41D  A DISBUF EQU    $E41D
0007          E419  A MNPTR EQU     $E419
0008          FOBB  A PUT   EQU     $FOBB
0009          *
0010          *
0011A 0000 CE 7679 A BEG    LDX     #$7679  "HE"
0012A 0003 FF E41D A      STX     DISBUF  STORE TO FIRST 2 DISPLAYS
0013A 0006 CE 3873 A      LDX     #$3873  "LP"
0014A 0009 FF E41F A      STX     DISBUF+2
0015A 000C CE 4040 A      LDX     #$4040  "--"
0016A 000F FF E421 A      STX     DISBUF+4 STORE TO LAST 2 DISPLAYS
0017A 0012 CE FOA2 A      LDX     #DIDDLE ADDR OF DIDDLE ROUTINE
0018A 0015 FF E419 A      STX     MNPTR  ESTABLISH AS ACTIVE SUB OF PUT
0019A 0018 7E FOBB A      JMP     PUT    CALL DISPLAY ROUTINE
0020          END

```

```

0000 BEG      0011*
FOA2 DIDDLE  0005* 0017
E41D DISBUF  0006* 0012 0014 0016
E419 MNPTR   0007* 0018
FOBB PUT     0008* 0019

```

After entering this program into memory using Memory Change, press "0" and "GO" to begin execution.

Display and Programming Examples (cont'd)

To help in better understanding the PUT/MNPTR routine operation, try the following:

DIDDLE has been used so far as the subroutine which is executed once each millisecond from PUT. Now substitute a long delay using the DLYX routine as the subroutine which is specified by MNPTR.

```
0020 CE FFFF SLOW LDX #$FFFF For 1/2 second delay
0023 BD F179      JSR DLYX Delay
0026 39          RTS      Then return to PUT
```

To install SLOW as the active subprogram of PUT, just change the third last step of the "HELP --" program:

was:

```
0012 CE FOA2 LDX #DIDDLE Addr of DIDDLE routine
```

to:

```
0012 CE 0020 LDX #SLOW Addr of SLOW routine
```

When the program is running between successive digits (which are on for about 1 millisecond) there is an approximately half second delay.

Adjust the amount of delay by changing FFFF at 0021,2 and observe the effect.

This example is a clock program to display time in a 24-hour format. The program is as follows (next page):

TIME

0001				NAM	TIME	
0002				OPT	LLEN=80, CREF	
0003A 0000				ORG	\$0	
0004				* D5BUG ROUTINE		
0005	F0BB	A	PUT	EQU	\$F0BB	
0006	E419	A	MNPTR	EQU	\$E419	
0007	E42C	A	HEXBUF	EQU	\$E42C	
0008	F120	A	DYSCOD	EQU	\$F120	
0009A 0000	0001	A	RHR	RMB	1	HOURS
0010A 0001	0001	A	RMIN	RMB	1	MINUTES
0011A 0002	0001	A	RSEC	RMB	1	SECONDS
0012A 0003	0002	A	TICK	RMB	2	COUNTERPASSES; ABOUT 1ms/PASS
0013						
0014A 0005	CE 000E	A	START	LDX	#TIME	ADDR OF TIME ROUTINE
0015A 0008	FF E419	A		STX	MNPTR	ESTABLISH AS ACTIVE SUB
0016A 000B	7E F0BB	A		JMP	PUT	GET STARTED
0017						
0018A 000E	DE 03	A	TIME	LDX	TICK	# OF PASSES
0019A 0010	08			INX		INCREMENT # PASSES
0020A 0011	DF 03	A		STX	TICK	UPDATE
0021A 0013	8C 0217	A		CPX	#535	PASSES/SEC
0022A 0016	26 4C 0064			BNE	TBOT	TO BOTTOM OF PROG
0023A 0018	CE 0000	A		LDX	#0000	
0024A 001B	DF 03	A		STX	TICK	RESET TICK COUNT
0025A 001D	7C 0002	A		INC	RSEC	INCREMENT SECONDS
0026A 0020	96 02	A		LDAA	RSEC	
0027A 0022	8A F5	A		ORAA	#\$F5	CHECK FOR BCD OVERFLOW
0028A 0024	43			COMA		
0029A 0025	26 3D 0064			BNE	TBOT	IF NOT \$xA SECONDS
0030A 0027	96 02	A		LDAA	RSEC	
0031A 0029	8B 06	A		ADDA	#6	INCREMENT TENS DIGIT
0032A 002B	97 02	A		STAA	RSEC	UPDATE
0033A 002D	81 60	A		CMPA	#\$60	60 SEC YET ?
0034A 002F	26 33 0064			BNE	TBOT	IF NOT; EXIT
0035A 0031	7F 0002	A		CLR	RSEC	RESET SCONDS COUNT
0036A 0034	7C 0001	A		INC	RMIN	NEW MINUTE
0037A 0037	96 01	A		LDAA	RMIN	
0038A 0039	8A F5	A		ORAA	#\$F5	CHECK FOR BCD OVERFLOW
0039A 003B	43			COMA		
0040A 003C	26 26 0064			BNE	TBOT	IF NOT; EXIT
0041A 003E	96 01	A		LDAA	RMIN	
0042A 0040	8B 06	A		ADDA	#6	INCREMENT TENS DIGIT
0043A 0042	97 01	A		STAA	RMIN	UPDATE
0044A 0044	81 60	A		CMPA	#\$60	60 MIN YET ?
0045A 0046	26 1C 0064			BNE	TBOT	IF NOT; EXIT
0046A 0048	7F 0001	A		CLR	RMIN	RESET MINUTES COUNT
0047A 004B	7C 0000	A		INC	RHR	NEW HOUR
0048A 004E	96 00	A		LDAA	RHR	
0049A 0050	8A F5	A		ORAA	#\$F5	CHECK FOR BCD OVERFLOW
0050A 0052	43			COMA		
0051A 0053	26 06 005B			BNE	CHKHR	CHECK FOR END OF A DAY
0052A 0055	96 00	A		LDAA	RHR	
0053A 0057	8B 06	A		ADDA	#6	INCREMENT TENS DIGIT
0054A 0059	97 00	A		STAA	RHR	UPDATE HOURS
0055A 005B	96 00	A	CHKHR	LDAA	RHR	
0056A 005D	81 24	A		CMPA	#\$24	END OF A DAY ?
0057A 005F	26 03 0064			BNE	TBOT	
0058A 0061	7F 0000	A		CLR	RHR	RESET HOURS

TIME

```

0059A 0064 DE 00      A TBOT   LDX      RHR      HOURS/MINUTES
0060A 0066 FF E42C   A        STX      HEXBUF   TO HEX BUFFER
0061A 0069 96 02     A        LDAA     RSEC      SECONDS
0062A 006B B7 E42E   A        STAA     HEXBUF+2 TO LAST DIGITS
0063A 006E 7E F120   A        JMP      DYSCOD   CONVERT TO 7-SEG
0064                      * YOU WILL RETURN TO PUT AT CONCLUSION OF DYSCOD
0065                      END

```

ERRORS 00000--00000

```

005B CHKHR      0051 0055*
F120 DYSCOD     0008* 0063
E42C HEXBUF     0007* 0060 0062
E419 MNPTR      0006* 0015
FOBB PUT        0005* 0016
0000 RHR        0009* 0047 0048 0052 0054 0055 0058 0059
0001 RMIN       0010* 0036 0037 0041 0043 0046
0002 RSEC       0011* 0025 0026 0030 0032 0035 0061
0005 START      0014*
0064 TBOT       0022 0029 0034 0040 0045 0057 0059*
0003 TICK       0012* 0018 0020 0024
000E TIME       0014 0018*

```

After entering this program into memory using Memory Change, press "5" and "GO" to begin execution.

Comments on 24 hour clock program "TIME"

The technique used to measure time is called "software timing" and relies on the system clock accuracy and the sum of the execution times on all of the instructions being performed. This is a cumbersome technique to do right.

Determine all the different paths through the program in order to accurately predict the program's total execution time.

This is precisely the technique used in some digital watches, but in that case there is a fine adjustment to tune the clock frequency to better than .001% which comes out to about 5 minutes per year. In a typical microprocessor system, the clock speed is not adjustable and accuracy is about 0.1% which comes out to more than a minute a day.

As for calculating actual program execution time, look at the program to see how many different paths there are just from the label "TIME" to "TBOT":

1. Not end of tick.
2. End of tick, not end of minute, not a tenth second.
3. End of tick, not end of minute, second tens digit incr.
4. End of tick, end of minute, not end of hour, not a tenth minute.
5. End tick, end minute, not end hour, minute tens digit incr.
6. End tick, end minute, end hour, not end day, not a tenth hour.
7. End tick, end minute, end hour, end day.

Each of the above paths through the TIME program takes a different length of time because a different sequence of instructions is followed. That's just part of the task; to completely calculate the execution time, do the same thing to every routine being executed. Then to find the total, determine exactly how many times each path is followed and add up all those times.

CHAPTER 4

THEORY OF OPERATION

4.1 General

The MEK6802D5 allows the user to become familiar with the MC6800 family of microprocessors. Refer to the block diagram, Figure 4.1, and the component function location diagram, Figure 4.2.

The three basic components of the D5 are (1) U5, the MC6802 microprocessor, (2) U12, the MC68A1316E ROM, and (3) U23, the MC6821 PIA.

The MC6802 is the heart of the D5 system. The MC6802 is an eight (8)-bit microprocessor that can execute 72 different instructions (exact instruction set of the MC6800). Included are binary and decimal arithmetic, logical, shift, rotate, load, store, conditional or unconditional branch, interrupt and stack manipulation instructions.

The MC6802 has a set of registers and accumulators plus an internal clock oscillator and driver.

For a more detailed explanation and description of the MC6802 Microprocessor refer to the data sheet located at the end of this manual.

The MEK6802D5 utilizes a 3.58 MHz crystal (Y1) to control this circuitry (this results in a system operating speed of 895 KHz). Power on/reset is accomplished by components R1 and C17.

Basic to the operation of the D5 system is the Data bus (eight lines labeled BD0 through BD7) and the Address bus (sixteen lines labeled BA0 through BA15). These buses interconnect to the various sections.

The address bus is further decoded by the Address Decode Logic (U6) into select lines. J2 and J3 must be set properly to accomplish this. These jumpers are specified in the installation section of this manual for the various board arrangements possible.

The ROM section is the permanent data storage. Unlike some types of memories, this ROM retains data whether the power is on or not.

The ROM section consists of the D5BUG Monitor (U12) and the optional User ROM (U13). J4 is used to configure the user ROM socket to accept various types of ROMs or EPROMs. J2 is used to position U13 (user ROM) in memory space. J3 is used to position U12 (D5BUG) in memory space.

The RAM section consists of a 128 byte static Random Access Memory. This memory will retain its stored data as long as power is supplied to it and can be written into and read out of as desired.

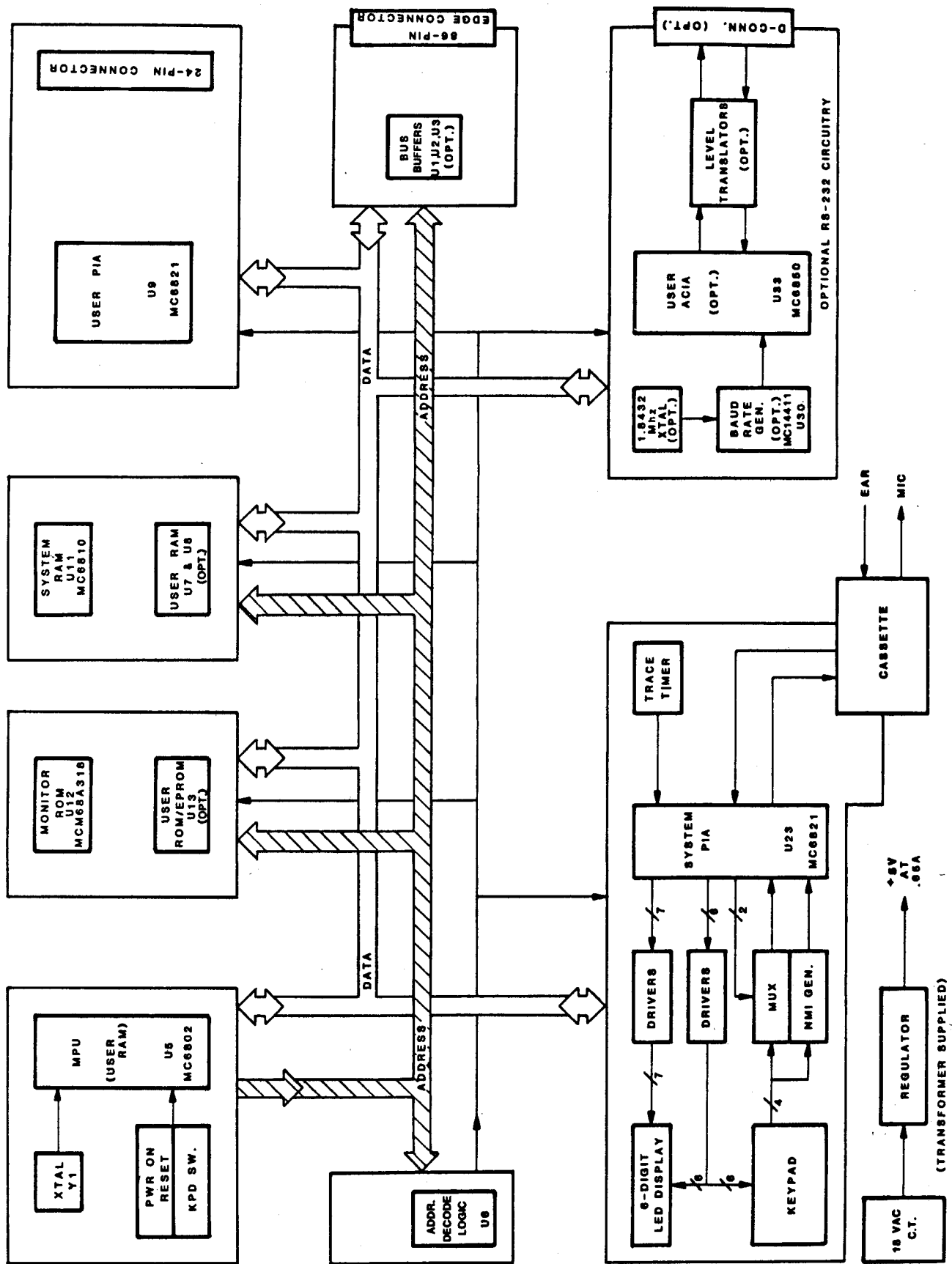


FIGURE 4.1. BLOCK DIAGRAM

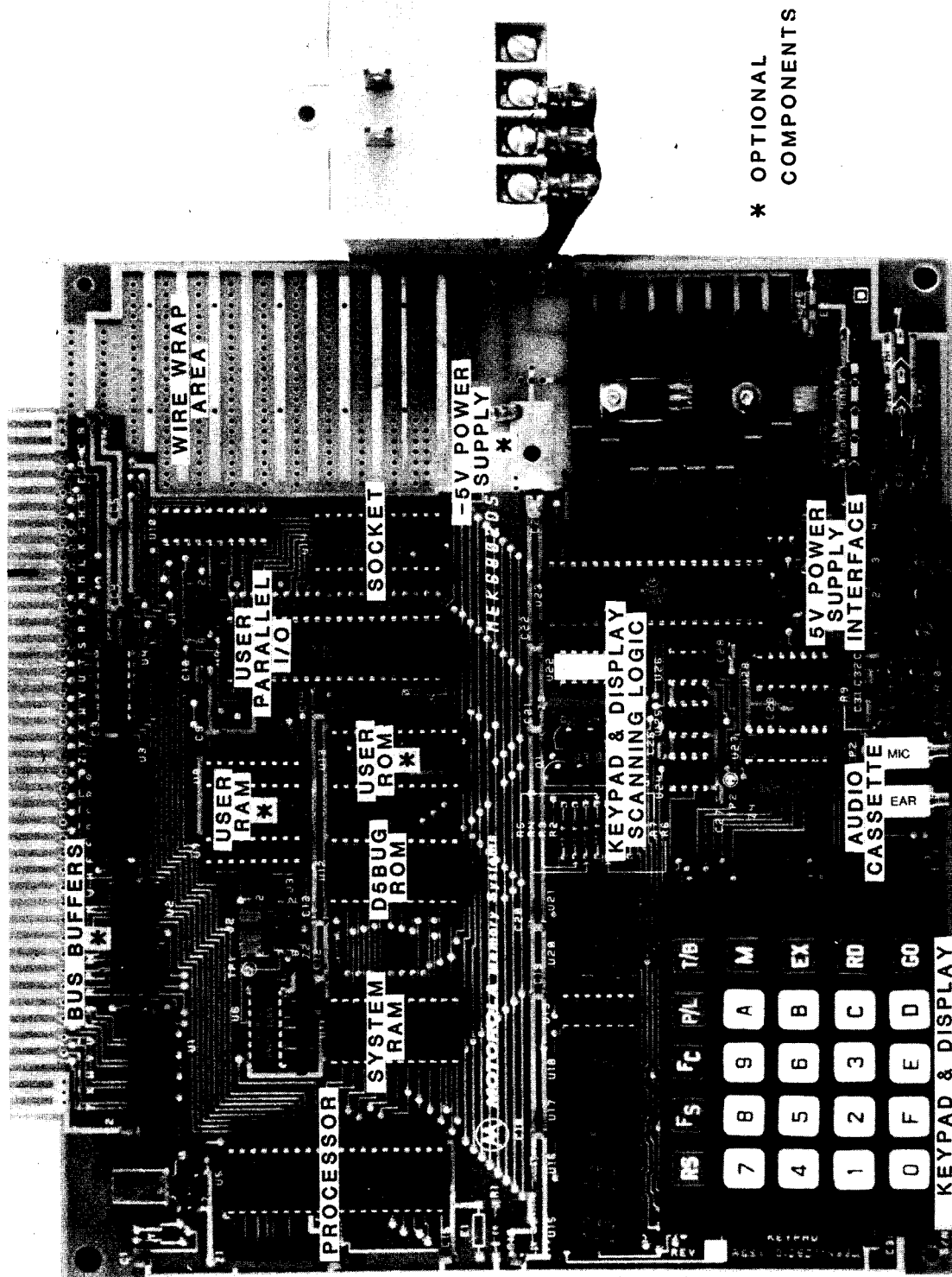


FIGURE 4.2. COMPONENT FUNCTION LOCATION DIAGRAM

The D5 uses this RAM as a Scratch Pad, which is a temporary storage for program material being processed. An example of this could be a program that uses a set of data a large number of times during the running of the whole program. This device would allow that data to be referred to as needed, rather than being repeated over again in the main program.

Another optional feature is the User RAM (U7 and U8). This provides the user with an additional (1K) bytes of memory. This feature is valuable when long programs must be stored.

These memories are volatile, and power must be supplied to them to retain their stored data.

The system PIA has two 8-line I/O ports and four control I/O lines for a total of 20 interface lines. The four control lines provide for a variety of hand shake applications. The two I/O ports are controlled by software to configure these 16 lines as inputs or outputs in any combination.

The User PIA (U9), allows the processor to talk to the outside world. The 16 I/O lines and 4 control lines are connected to a 24-pin socket (U14).

The optional Bus Buffers (U1, U2, U3) are for expanding the D5 through an 86-pin edge connector. This is accomplished by plugging an IC in the supplied sockets. Note that U10, also a bus driver, is part of the basic D5 since the processor's R/W output cannot drive all the inputs in the basic system (or the bus). All the control signals, data, and addresses are available on this bus for system expansion.

The system PIA, (U23) uses its A side to drive the anode segments of the LED displays and the B side to drive the LED cathodes. The processor put data into the register of the PIA to display on one of the LED's, then places data in the PIA registers to drive the next display element, etc., at a rapid enough rate that the display appears steady.

The keypad is connected to the cathode drivers of the LED's so that when a key is depressed, an interrupt signal is generated. This interrupt signal causes the processor to call up a routine from D5BUG, which then enables it to search for the key that was closed. The PIA is used to enter new data or display data in the system.

The D5 can be supplied to interface to the widely used RS-232 bus. An Asynchronous Communications Interface Adapter (ACIA) converts the parallel data on the data bus to a serial form suitable for transmission

4.1 General (cont'd)

over a communications system. This ACIA will both transmit and receive data and allows the D5 to be used as a remotely controlled processor. An MC14411 Bit Rate Generator supplies the special frequency that the ACIA requires in making the conversion from parallel to serial data.

An installed jumper determines the frequency of data formatted in serial form. A socket allows cabling to the RS-232 line.

4.2 Addressing

The MEK6802D5 accesses 64K of memory space by use of 16 address lines A0 through A15. The addresses \$E000 to \$FFFF access parts on the MEK6802D5 and external data buffers are not enabled for such accesses. The area from \$0000 to \$007F is RAM within the MC6802 and must be disabled by jumper option if the optional bus buffers are installed.

When the optional edge connector bus buffers are installed, all accesses to addresses \$0000 to \$DFFF are considered to be off-board.

The system memory map is shown in Figure 4.3, the Address Decode Map in Table 4.1 and the System Timing Diagram in Figure 4.4.

4.2 Addressing (cont'd)

FFFF	Operating System Mirror (or optional user ROM)
F800	Operating System (D5BUG)
F7FF	
F000	Optional User ROM
FFFF	
E800	Reserved
E700-E701	System ACIA*
	Reserved
E487	
	System PIA
E484	
E483	User PIA
E480	
E47F	System RAM
E400	
E3FF	Optional User RAM (1K)
E000	
DFFF	External to MEK6802D5
0080	User RAM inside MC6802 (must be disabled if optional Bus buffers are installed)
007F	
0000	

*ACIA is not supported by D5BUG software.

FIGURE 4.3. MEMORY MAP

TABLE 4.1. ADDRESS DECODE MAP

Device	VMA	R/W	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0	U No.
MC68A316E	1	X	1	1	1	1	*	.	.	.	.	.	.	.	.	.	.	.	U12
MCM6810	1	.	1	1	1	0	0	1	0	0	0	.	.	.	.	.	.	.	U11
MC6821 (User)	1	.	1	1	1	0	0	1	X	X	1	X	X	X	X	0	.	.	U9
MC6821 (Syst)	1	.	1	1	1	0	0	1	X	X	1	X	X	X	X	1	.	.	U23
MCM2114 (Opt.)	1	.	1	1	1	0	0	0	.	.	.	.	.	.	.	.	.	.	U7,U8
User ROM (Opt. 1)	1	.	1	1	1	0	1	.	.	.	.	.	.	.	.	.	.	.	U13
User ROM (Opt. 2)	1	.	1	1	1	**	1	.	.	.	.	.	.	.	.	.	.	.	U13
MC6802***	1	.	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	U5
MCM6850 (Opt.)	1	.	1	1	1	0	0	1	1	1	1	0	X	X	X	X	X	X	U33
74LS245 (Opt.)	1	.	\$0000 - \$DFFF (Must install E1)																U3

0 - Logic zero 1 - Logic one . -Both X - Don't Care

* - Normally both but by removing jumpers it becomes 0 only.

** - 1 but monitor mirror must be disabled.

*** - Inherent to the MC6802 by design, may be disabled for system expansion.

TABLE 4.2. AC OPERATING CHARACTERISTICS

Parameter	Symbol	Min	Max	Unit
Cycle	TCYC	1100	1130	ns
Address Setup	TAS	220		ns
Address Hold	TAH	20		ns
Write Data Valid	TDVW		240	ns
Write Data Hold	TDHW	20		ns
Address Delay	TAD		290	ns

TABLE 4.3. AC OPERATING CONDITIONS

Parameter	Symbol	Min	Max	Unit
Access Time ⁴	TACC1		380	ns
	TACC2		710	ns
Data Hold Read ⁵	TDHR	0		ns

Test Conditions:

- 1) Operating temperature, TA = 25°C.
- 2) Timing signals measured at I/O connector (50% points).
- 3) I/O loading conditions equivalent to 74LS type devices.
- 4) Measured from the rising edge of E (Ø2).
- 5) Measured from the falling edge of E (Ø2).

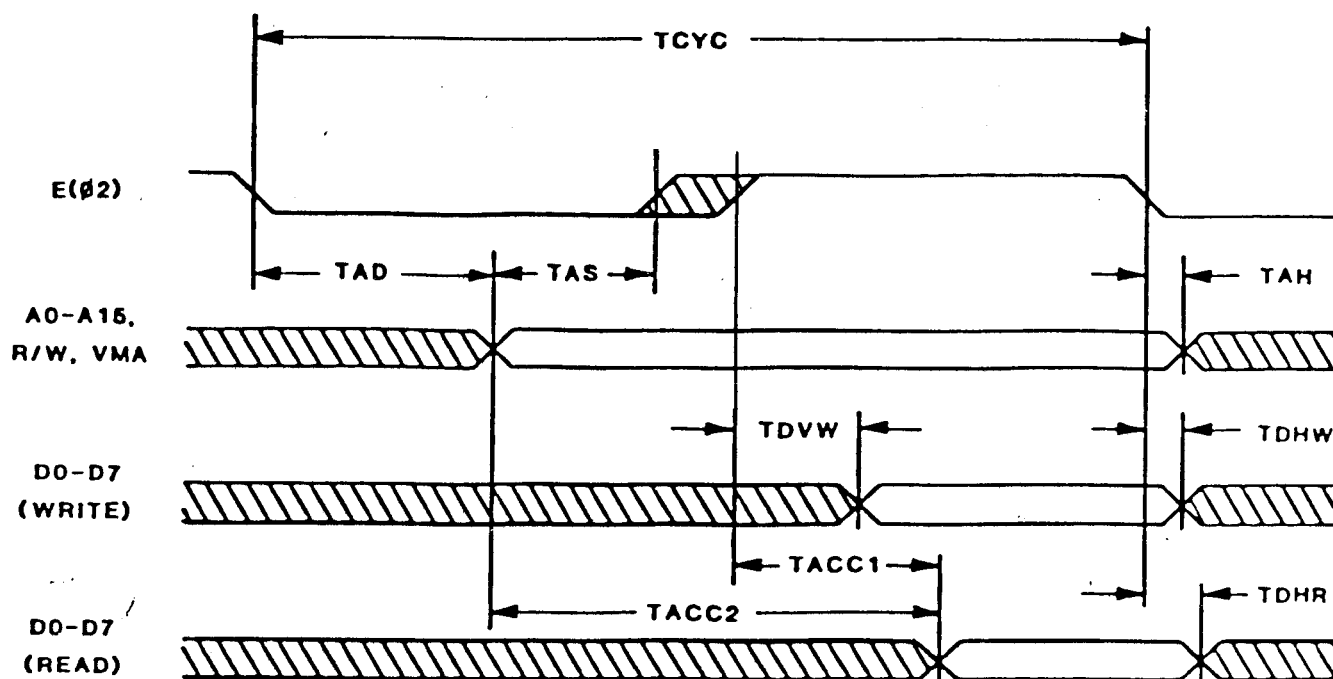


FIGURE 4.4. SYSTEM TIMING DIAGRAM

CHAPTER 5

MAINTENANCE

5.1 Troubleshooting

Troubleshooting techniques can be divided into several steps:

- a) Check and analyze operation.
- b) Test to isolate section, stage, and part.
- c) Replace the defective part.
- d) Performance test after repair.

For all troubleshooting, refer to the system schematic, Figure 5.1, and to the component location diagram, Figure 6.1, in Chapter 6.

Begin troubleshooting by checking the power supply voltages used with the D5. Check for secure and correct transformer connections.

The 86-pin edge connector fingers are tin lead plated and should be cleaned for reliable operation.

Use caution when replacing defective parts. Improper handling (refer to Chapter 2) and too much heat can destroy components.

5.2 Standard Logic Symbols

5.2.1 Digital Logic Circuits

All digital equipment, simple or complex, is constructed from a few basic devices. These devices consist of electronic circuitry that provides an output based on the input of one, two, or more variables and are called logic elements (most often referred to as gates).

Digital logic circuits are broken into two basic types: decision-making and memory elements. All decision logic elements monitor binary inputs and produce outputs based on the input states and the operational characteristics of the logic element. Memory elements are used to store binary data. Table 5.1 gives the basic logic elements, their more commonly used forms, and their single binary output. All other digital logic elements and circuits are variations or combinations of these basic elements.

TABLE 5.1. LOGIC SYMBOLS AND TRUTH TABLES


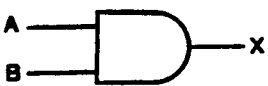




Device	Logic Symbol	Truth Table *		
		A	B	X
INVERTER		L H	--- ---	H L
AND		L H L H	L L H H	L L L H
OR		L H L H	L L H H	L H H H
NAND		L H L H	L L H H	H H H L
NOR		L H L H	L L H H	H L L L
XOR (EXCLUSIVE OR)		L H L H	L L H H	L H H L
<p>* The Truth Table is a table showing all possible combinations of inputs with the respective output for each set of inputs.</p> <p>H = High voltage (logic 1) L = Low voltage (logic 0)</p>				

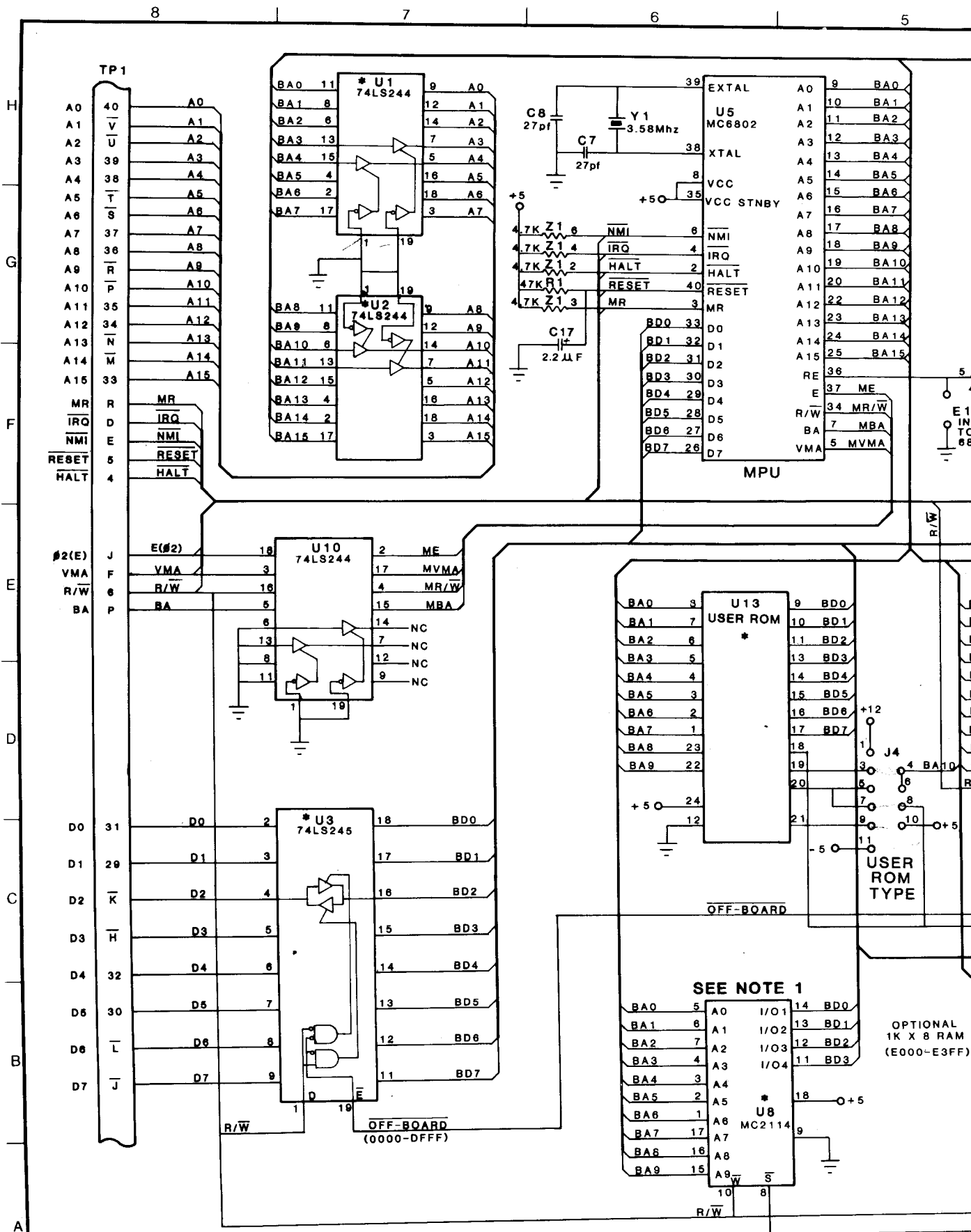
FIGURE 5.1. SCHEMATIC DIAGRAM

Sheet 1: Index Page

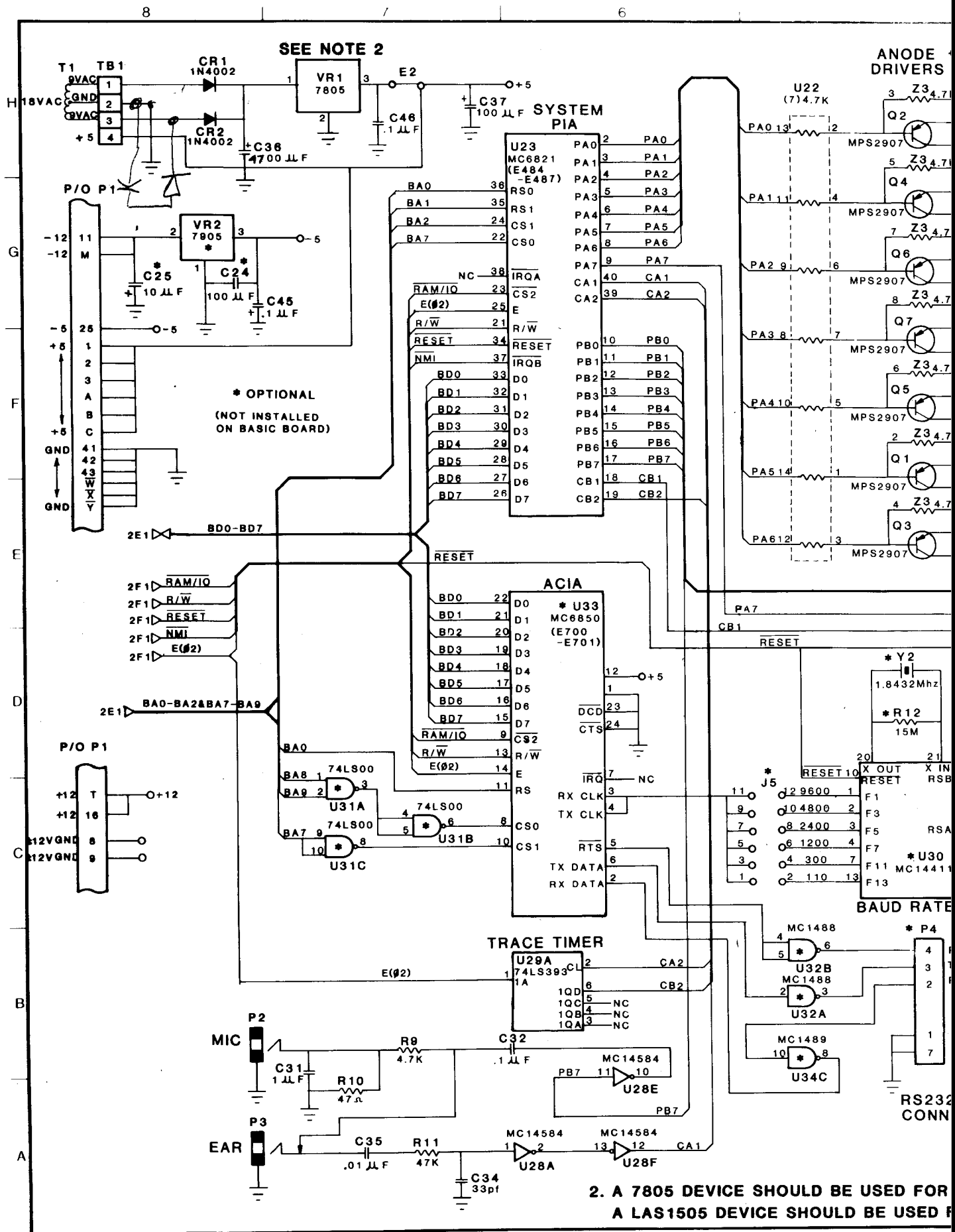
Sheet 2: Schematic Diagram

Sheet 3: Schematic Diagram

NOTE: This is sheet 1 of Figure 5.1. The
schematic diagram consists of 2 sheets.



1. U7 AND U8 ARE OPTIONAL FOR THE MEK6802D5,
STANDARD FOR THE MEK6802D5E.



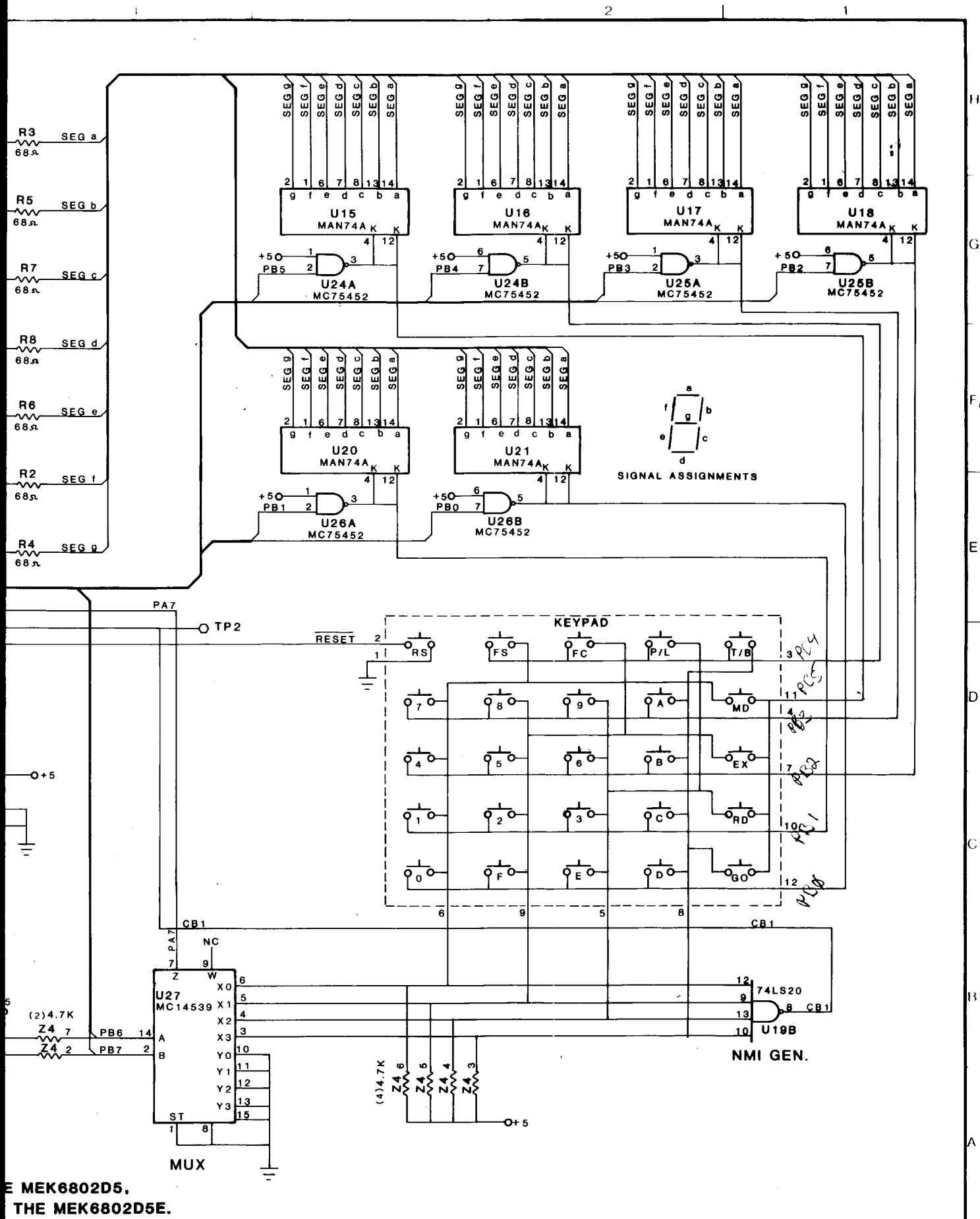


FIGURE 5.1 SCHEMATIC DIAGRAM
(SHEET 3 OF 3) 5-7/5-8

CHAPTER 6

PARTS LIST

6.1 General

This chapter consists of Figure 6.1, Board Outline and Component Layout, and Table 6.1, which is a listing of parts contained in the MEK6802D5 Microcomputer.

TABLE 6.1. MEK6802D5 PARTS LIST

Item No.	Quan.	Description	Part Number	Reference Designation
1	1	PC Board, Basic	MEK6802D5	--
2	1	Integrated Circuit	MCM68A316E	U12 (D5BUG)
3	1	Integrated Circuit	74LS00	U4
4	1	Integrated Circuit	74LS20	U19
5	1	Integrated Circuit	74LS156	U6
6	1	Integrated Circuit	74LS393	U29
7	1	Integrated Circuit	MC6802	U5
8	2	Integrated Circuit	MC6821P	U23, U9
9	1	Integrated Circuit	MC6810	U11
10	3	Integrated Circuit	75452	U24, U25, U26
11	1	Integrated Circuit	MC14539	U27
12	1	Integrated Circuit	74LS244	U10
13	1	Integrated Circuit	MC14584	U28
14	1	Resistor, 4.7K 1/4 Watt, 5%		R9
15	1	Resistor, 47 ohm 1/4 Watt, 5%		R10

TABLE 6.1. MEK6802D5 PARTS LIST (cont'd)

Item No.	Quan.	Description	Part Number	Reference Designation
16	2	Resister, 47K 1/4 Watt, 5%		R1, R11
17	7	Resister, 68 ohm 1/4 Watt, 5%		R2,R3,R4,R5, R6,R7,R8
18	3	Resister Package, SIP, 4.7K		Z1,Z3,Z4
19	1	Resister Package, SIP, 4.7K		Z2
20	1	Resistor Package, DIP, 4.7K		U22
21	1	Capacitor, 33 pF, Mica		C34
22	1	Capacitor, 0.01 uF, Mono (ceramic)		C35
23	2	Capacitor, 27 pF, Mica		C7,C8
24	30	Capacitor, 0.1 uF, Mono (ceramic)		C1-C6,C9-C16, C18-C23,C26- C30,C32,C33, C38,C45,C46
25	1	Capacitor, 100 uF, 35 V, Elect		C37
26	1	Capacitor, 2.2 pF		C17
27	1	Capacitor, 1.0 uF, Mono (ceramic)		C31
28	1	Capacitor, 4700 uF, 16 V		C36
29	3	Socket, IC, 20-pin		U1-U3
30	2	Socket, IC, 18-pin		U7-U8

TABLE 6.1. MEK6802D5 PARTS LIST (cont'd)

Item No.	Quan.	Description	Part Number	Reference Designation
31	4	Socket, IC, 24-pin	Man 74A	U11-U14
32	3	Socket, IC, 40-pin		U5,U9,U23
33	3	Mini-jump		J2
34	2	Phone Jack, Enclosed		P2,P3
35	2	Test Point, White		TP1, TP2
36	1	Crystal, 3.579 MHz		Y1
37	1	Waffer Assy, 6		J4
38	7	Waffer Assy, 4		J1-4
39	6	LED, 7-segment		U15-U18, U20-U21
40	1	Hex Keypad		
41	1	Transformer		T1
42	1	Cable Assy, 3 Conductor		
43	1	Terminal Block, 4 Position		TB1
44	1	Voltage Regulator +5 V	7805	VR1
45	2	Diode	1N4002	CR1, CR2
46	1	Jumper, Zero ohm		E2
47	7	Transistor	MPS 2907	Q1-Q7
48	1	Heat Sink		VR1

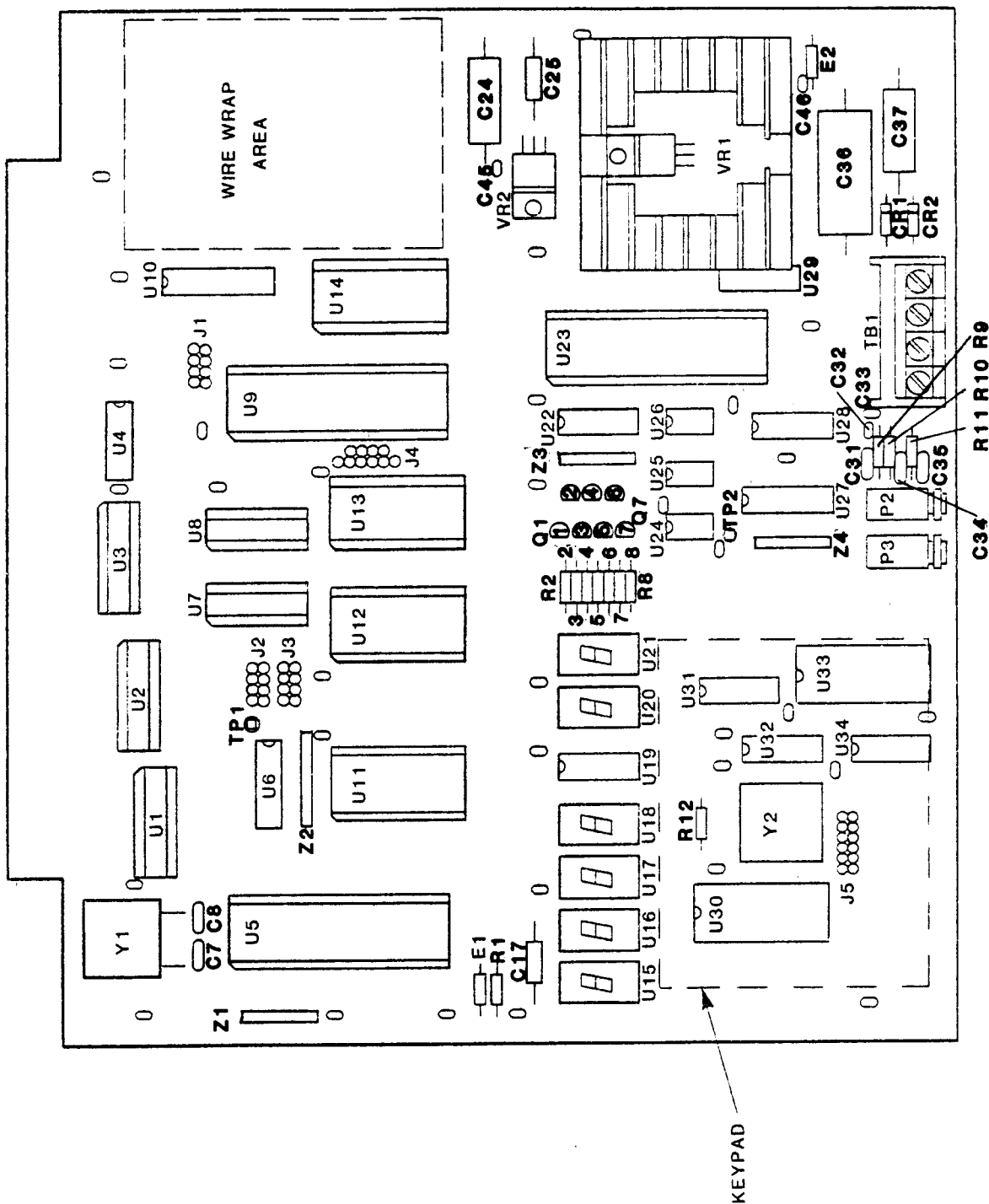


FIGURE 6.1. BOARD OUTLINE AND COMPONENT LAYOUT

CHAPTER 7

SOFTWARE LISTING AND DESCRIPTIONS

7.1 General

This chapter consists of the subroutine descriptions, the D5BUG software listing, and other useful information for the MEK6802D5.

7.2 Subroutine Descriptions

7.2.1 RESET (\$F000)

Routine: Hardware Reset (cold start)

Description: Sets interrupt mask
Clears all RAM from \$E400-E47F
Initializes system PIA
Establishes default user stack pointer (\$E418)
Passes control to PROMPT routine

7.2.2 PROMPT (\$F024)

Routine: Software Reset (warm start)

Description: Initializes system stack pointer (\$E47E)
Sets-up software flags:
ROLPAS = 1
UPROG = 0
ROIFLG = 0
KYFLG = 0
FNCFL = 0
Clears 7 -Seg displays
Displays prompt symbol (-)
Establishes FUNSEL as active main program

7.2.3 GET (\$F04E)

Routine: Subroutine to read, decode, and debounce a keypad switch.

Effects: All registers are altered by this routine. The A-register has the key code in it on return.

RAM location KYFLG will have \$01 in it on return and the code of the key that was depressed will be in location KEY.

7.2.3 GET (cont'd)

Routines Called: DLY25

Stack Requirement: 4 bytes.

Description: The keys of the keypad are electrically arranged into 6 rows and 4 columns. The "RS" (reset) key is not part of this row/column arrangement. GET is called when a key is depressed and the return does not take place until about 25 milliseconds after the key is released. While the key is closed, GET searches the matrix to find the key's row then its column. The Row/Column information is used to address a look-up table from which a key code value is fetched.

This code is stored to the RAM location KEY and is also in the A-register when GET returns. A RAM location called KYFLG is set to \$01 to indicate that a key was entered, when another routine recognizes this flag, it should read the KEY code and clear KYFLG, to acknowledge that the key was seen.

Normally the GET routine is serviced through an NMI which results when any key is closed but the interrupt output of the KPD PIA could be disabled allowing GET to work on a polled basis. Polling means that periodically the PIA's control register is read ("Polled") to see if a key was depressed since the last time the program looked.

Calling Routines: NMINT

KEY CODE SUMMARY

KEY	ROW	COL	"CODE"
0	0	0	00
F	0	1	0F
E	0	2	0E
D	0	3	0D
1	1	0	01
2	1	1	02
3	1	2	03
C	1	3	0C
4	2	0	04
5	2	1	05
6	2	2	06
B	2	3	0B
7	3	0	07
8	3	1	08
9	3	2	09
A	3	3	0A
FS	4	0	84
FC	4	1	85
P/L	4	2	86
T/B	4	3	87
MD	5	0	80
EX	5	1	81
RD	5	2	82
GO	5	3	83

FUNCTION KEYS

KEY	"CODE"
MD	80
EX	81
RD	82
GO	83
FS	84
FC	85
P/L	86
T/B	87

NOTE: Function codes have MSB set to allow testing neg cond code

FIGURE 7.1. KEY CODE AND FUNCTION SUMMARY

7.2.4 PUT (\$FOBB)

Routine: Utility program to display information on the 7-segment displays and call the active main program as a subroutine once each millisecond.

Effects: The A, B, and X-registers are altered by PUT.

Routines Called: DLY1, routine specified by MNPTR.

Stack Requirement: 1 in addition to main program requirement (Minimum-3 bytes total).

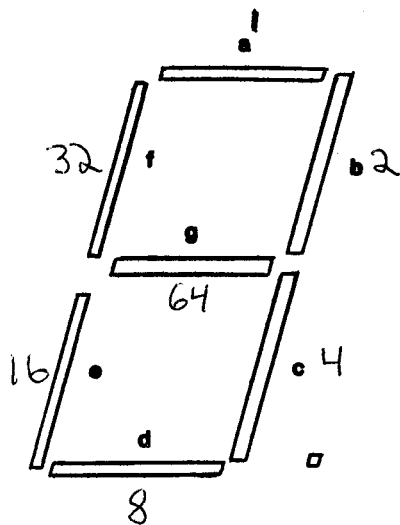
Description: The PUT routine is the heart of the operating system because the displays must be continuously scanned. Anode information for the desired display is presented to the parallel anode lines and the appropriate cathode is driven turning on the proper segments. A given digit is turned on for about one millisecond then the cathode is disabled, the anode information changed to that of the next digit, and the next cathode is enabled.

During the short period between digits a subroutine whose address is stored at RAM location MNPTR is executed. Upon RESET or PROMPT, MNPTR is set to the address of the function select routine (FUNSEL). When FUNSEL wishes to pass control to some other routine, it stores the address of that routine at MNPTR which 'activates' the new routine (and de-activates FUNSEL).

Another way of putting this is to say that the display routine calls 'some program' once per millisecond and 'some program' is the program whose address is stored at RAM location MNPTR.

The PUT routine obtains the segment information from a 6-byte buffer called DISBUF, which contains 7-segment data for the displays with the first byte corresponding to the leftmost display. In addition the B-register keeps track of which digit is to be enabled with the third-from-the-left bit corresponding to the leftmost display and the LSB corresponding to the rightmost display.

NOTICE: The anode interface drivers are ground true so the PUT routine inverts the data in DISBUF before it is stored to the hardware so that the data in DISBUF will be high true.



D.P. not used on MEK6802D5

MSB							LSB
Not							
Used	g	f	e	d	c	b	a
	64	32	16	8	4	2	1

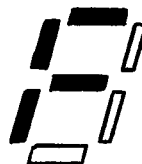
A high (1) in a bit location corresponds to a lighted display segment (for DISBUF only)

7-segment bit relationship to display

EXAMPLE: To display the character "F" the data in DISBUF would be:

a - 1
b - 0
c - 0
d - 0
e - 1
f - 1
g - 1

Not
Used - don't care; make 0



01110001 or \$71

FIGURE 7.2. CHARACTER DISPLAY

7.2.5 DYSCOD (\$F120)

Routine: Convert hexadecimal data from HEXBUF into 7-segment codes and store in DISBUF.

Effects: The contents of the A, B, and X-registers are saved and restored prior to returning from DYSCOD.

On return the RAM locations DISBUF through DISBUF+5 contain the 7-segment codes for the hexadecimal information in HEXBUF through HEXBUF+2.

Routines Called: ADDAX

Stack Requirement: 9 bytes.

Description: The six nibbles of hexadecimal information from HEXBUF through HEXBUF+2 are each converted to a byte of 7-segment anode information which is stored in the six byte display buffer (DISBUF). The most significant 4 bits of location HEXBUF correspond to the location DISBUF and the least significant 4 bits of HEXBUF+2 correspond to the location DISBUF+5.

The resulting 7-segment information is displayed on the D5's six LED displays by the PUT routine. The first byte of DISBUF corresponds to the leftmost display and the sixth byte (DISBUF+5) corresponds to the rightmost display.

7.2.6 DLY25, DLY1, DLYX (\$F169) (\$F171) (\$F179)

Routine: These routines cause delays of 25 milliseconds, one (1) millisecond, or a variable delay based on the value in the X-register.

Effects: The contents of the X-register are saved and restored prior to returning from the routines. The A and B-registers are not altered by the delay routines.

Stack Requirement: 2 bytes.

Description: Calling DLY25 or DLY1 will cause an execution time delay of about 25 milliseconds or 1 millisecond respectively. Calling DLYX will cause a delay based on the value in the X-register according to the following formula:

$$[(X-1) (8 \text{ cyc}) (1.11763 \text{ us/cyc})] + (27.94 \text{ us})$$

7.2.6 DLY25, DLY1, DLYX (cont'd)

A minimum delay of 27.94 us results from an X-register value of 1 (\$0001) and a maximum delay of 0.5842 seconds results from an X-register value of 0 (\$0000 - 1 = \$FFFF = 65,535).

7.2.7 ADDAX (\$F183)

Routine: Add A-register to X-register.

Effects: A and X-registers altered by ADDAX.

Stack Requirement: 2 bytes.

Description: The value in the A-register is added to the value in the X-register and the result is returned in the X-register.

7.2.8 CLRDS (\$F195)

Routine: Clear LED display digits per a mask in the A-register.

Effects: The A-register is altered by CLRDS.

The contents of the X-register are saved and restored prior to returning from CLRDS.

Stack Requirement: 2 bytes.

Description: Each of the low order six bits of the A-register correspond to one of the D5's LED displays with the LSB of the A-register corresponding to the rightmost display. For each bit that is a logic 1, the corresponding display buffer location will be cleared resulting in that display going dark.

Example: 0011 1100 (\$3C) would clear the first four LED displays.

7.2.9 ROLL2 (\$F1AA)

Routine: Numeric entry routine for 2-digit (1-byte) values.

Requirements: Least significant 4-bits of A-register contain the new hexadecimal digit and the most significant 4-bits must be cleared.

7.2.9 ROLL2 (cont'd)

ROLPAS flag (when set) indicates "first pass" which results in the location being cleared prior to rolling the new digit in from right.

Effects: A-register altered by ROLL2, X-register contents saved and restored prior to return from ROLL2.

Stack Requirement: 2 bytes.

Description: The address of the location to be operated on by ROLL2 is specified in HEXBUF and HEXBUF+1. A new hex digit is passed to ROLL2 in the least significant 4-bits of the A-register. This new digit is shifted in from the right so that the digit which was in the least significant 4-bits of the location is now in the most significant 4-bits. The digit which was in the most significant 4-bits is lost.

If the flag ROLPAS was not equal to zero, then the location is cleared before the new digit is rolled in. ROLPAS is cleared to signal it is no longer the first pass.

7.2.10 ROLL4

(\$F1CC)

Routine: Numeric entry routine for 4-digit (2-byte) values.

Requirements: ROLPAS flag (when set) indicates "first pass" which results in the locations HEXBUF and HEXBUF+1 being cleared prior to rolling the new digit in from the right.

The least significant 4-bits of the A-register contains the new digit and the most significant 4-bits of the A-register must be cleared.

Effects: A-register is altered by ROLL4, B-register is saved and restored prior to returning from ROLL4.

Stack Requirement: 3 bytes.

Description: The locations into which ROLL4 shifts the new digit are HEXBUF and HEXBUF+1. The new digit is passed to ROLL4 in the least significant 4-bits of the A-register. This new digit is shifted into the first two bytes of HEXBUF such that the new digit ends up in the least significant 4-bits of HEXBUF+1. What was in the low 4-bits ends up in the high 4-bits of HEXBUF+1 and what was in the high 4-bits of HEXBUF+1

7.2.10 ROLL4 (cont'd)

ends up in the low 4-bits of HEXBUF. What was in the low 4-bits of HEXBUF ends up in the high 4-bits of HEXBUF, and what was in the high 4-bits of HEXBUF is lost.

If the ROLPAS flag was not equal to zero then HEXBUF and HEXBUF+1 will be cleared prior to shifting in the new digit, and ROLPAS will be cleared to indicate no longer first pass.

7.2.11 RDKEY

(\$F1EF)

Routine: Read and acknowledge a keypad key.

Requirements: Normally RDKEY would be called because KYFLG was set indicating that a key had been depressed.

Effects: KEY value returned in A-register.

KYFLG cleared to acknowledge that the key has been recognized.

Stack Requirement: 2 bytes.

Description: Load the key code from KEY into the A-register and clear KYFLG to acknowledge that the key has been recognized.

7.2.12 TIN

(\$F533)

Routine: Read 1 byte of data from tape.

Effects: The A and B-register contents are altered by TIN.

On return the location BYTE (\$E459) contains the character that was recovered from tape. The A-register also contains the recovered data.

Routines Called: FEDGE

Stack Requirement: 4 Bytes.

Description: TIN is used to read 1 Kansas City standard format character from cassette tape. The character format is:

a) Logic 0 Bit-Time = 4 cycles of 1200 Hz.

7.2.12 TIN (cont'd)

b) Logic 1 Bit-Time = 8 cycles of 2400 Hz.

c) Characters consist of:

- i) 1 Logic 0 Bit-Time as a "Start" bit.
- ii) 8 Data Bit-Times (LSB first).
- iii) At least 2 logic 1 Bit-Times as "Stop" Bits.

Software timing techniques are used and an error tolerant algorithm is employed to assure reliable data recovery. The TIN routine is in control from before a start bit until just after the eighth data bit in the serial stream.

During the stop bit-times the previous data character is processed by other software. At the 300 Baud data rate the stop bits take 13.3 milliseconds.

When reading successive data characters, the software which processes the previous byte read must finish in time to call TIN at least one full cycle before the next start bit-time. This will allow TIN to regain synchronization with the serial data stream.

The time required from the last cycle of the instruction that calls TIN until the first test for an edge is exactly 47 processor cycles or 52.5 microseconds.

The time from the end of the last cycle of the last data bit-time until the completion of TIN's RTS instruction is 100 cycles or 111.2 microseconds.

Generally it will be easy to process the previous character in time to get back to TIN for the succeeding character.

7.2.13 PNCHB

(\$F608)

Routine:	Format and send one byte of data to the tape interface.
Effects:	The contents of the A and B-registers are altered during PNCHB.
Routines Called:	BIT0, BIT1, INVRT.
Stack Requirement:	6 bytes.

7.2.13 PNCHB (cont'd)

Description: Refer to the description of TIN for the format of tape characters.

Software timing techniques are used to create a serial stream of cycles of the proper duration to form Kansas City Standard audio signals.

When punching consecutive bytes of data it is vital to maintain timing control between successive bytes, not just within the character.

PNCHB consumes exactly 35 MPU cycles from the last MPU cycle of the calling instruction until the first start bit edge is sent. Timing is then automatically controlled by PNCHB while the character is being transmitted.

After transmitting the second last edge of the last stop bit PNCHB returns. The edge which marks the completion of the last stop bit cycle also marks the beginning of the succeeding start bit for the next character. It is supplied as the first edge transmitted by the next call to PNCHB.

The time allowed from the last cycle of PNCHB's RTS until the next edge must be transmitted is exactly 159 MPU cycles.

159 minus the 35 for entry to PNCHB the next time leaves exactly 124 cycles which must be consumed by external software. For example, if it takes 50 cycles to set up for the next character, the remaining 74 (124-50) cycles must be consumed in dummy delays before calling PNCHB again.

7.2.14 PUNCH (\$F630)

Routine: Format and punch an entire file to the cassette.

Effects: The A, B, and X-register contents are altered during PUNCH.

Routines Called: PNCHB

Stack Requirement: 8 Bytes.

Description: PUNCH is a time-tuned subroutine.

7.2.14 PUNCH (cont'd)

Before calling PUNCH store the beginning address of the data to be punched at RAM location BEGAD (\$E460,1) and the ending address at ENDAD (\$E462,3).

The file format is as follows:

- a) 30 seconds of \$FF characters as leader.
- b) Block start character "S" (\$53).
- c) Begin address high byte.
- d) Begin address low byte.
- e) End address high byte.
- f) End address low byte.
- g) Data in binary form starting with data at Begin address to and including data at End address.
- h) One byte checksum. Checksum is the two's complement summation of all data bytes plus the begin and end address characters. When loading, the simple sum of all data in the file starting with the first byte of the begin address and including the checksum character should be zero.

7.2.15 LOAD

(\$F69C)

Routine: Load or verify a D5 format tape file to memory from cassette.

Effects: The A, B, and X-register contents are altered by LOAD.

Routines Called: TIN.

Stack Requirement: 6 bytes.

Description: The LOAD routine is used to read a tape data file into memory or verify a tape file against the contents of memory. If the least significant bit of the flag FNCFL (\$E43E) is set, a load takes place, otherwise a verify is performed.

Normally if a checksum error is detected, an error message is displayed on the 7-segment LED's.

This may be overridden by setting the MSB of FNCFL (\$E43E) prior to calling LOAD. When the override feature is used, the Z condition code may be checked upon return from LOAD to determine if the load was acceptable. If Z is true the load was good.

GENERAL NOTE FOR CASSETTE ROUTINES

The cassette routines rely on critical execution time-tuning to work properly.

To use the individual routines outside the context of the D5BUG operating system, take care to abide by the timing requirements of the individual routines.

To assist in this effort, the number of processor cycles required by each instruction is presented as the first character(s) in the comment portion of each listing line for those routines.

7.3 Program Address Descriptions

TABLE 7.1. D5BUG USEFUL PROGRAM ADDRESSES
(Also Refer To Complete D5BUG Listing)

Name of Routine	ADDR in D5BUG	Description
RESET	\$F000	Cold Restart
PROMPT	\$F024	Warm Start
GET	\$F04E	Routine to Read a Key (Uses NMI routine so a user would not normally use this routine directly.
PUT	\$F0BB	Display Data on 7-segment readouts and calls functioning subroutines.
DYSCOD	\$F120	Decode Hex to 7-segment.
DLY25	\$F169	Delay 25 milliseconds.
DLY1	\$F171	Delay 1 millisecond.
DLYX	\$F179	Delay based on X-Reg (about 1/2 second Max).
ADDAX	\$F183	Add A-Register to X-Register.
CLRDS	\$F195	Clear display digits per A-Register mask.
ROLL2	\$F1AA	Numeric entry routine for 2-digit values (one byte). Address being operated on specified in "HEXBUF".
ROLL4	\$F1CC	Numeric entry routine for 4-digit values (2-Bytes).
RDKEY	\$F1EF	Read and acknowledge key.
TIN*	\$F533	Read 1 byte from tape.
PNCHB*	\$F630	Format and punch a whole file.
LOAD*	\$F69C	Load a whole file (if "FNCFL" \neq 0). Verify a whole file (if "FNCFL" = 0).
*Tape routines have critically tuned execution times. Refer to detailed explanations.		

7.4 Scratch RAM Descriptions

TABLE 7.2. SUMMARY OF MOST USED D5BUG SCRATCH RAM LOCATIONS
(Also See Complete D5BUG Listing)

Name of Routine	ADDR in D5BUG	Description
MNPTR	\$E419,A	Pointer to active sub-program.
KEY	\$E41B	Entered key code from keypad.
KYFLG	\$E41C	Flag to indicate a key is pending.
DISBUF	\$E41D-E422	(6) bytes correspond to (6) 7-segment displays. Contains 7-segment codes.
ROLPAS	\$E423	Flag to indicate first digit entry.
HEXBUF	\$E42C,D,E	3-byte buffer for hexadecimal information. Each byte corresponds to (2) 7-segment display digits.
USP	\$E42F,30	User stack pointer pseudo-register.
UCC	\$E431	User condition codes pseudo-register.
UB	\$E432	User B-register pseudo-register.
UA	\$E433	User A-register pseudo-register.
UX	\$E434,5	User X-register pseudo-register.
UPC	\$E436,7	User Program Counter pseudo-register.
UIRQV	\$E43C,D	Points to user's IRQ service routine.
FNCFL	\$E43E	Flag to indicate special (or alternate) function.
FNCPNT	\$E43F,40	Points to ADDR of user's special function table.
BYTE	\$E459	Data byte read from cassette or to be punched to cassette.
BEGAD	\$E460,1	Beginning Address (for punch).
ENDAD	\$E462,3	Ending Address (for punch).
*Tape routines have critically tuned execution times. Refer to detailed explanations.		

7.5 Hardware Address Information

TABLE 7.3. USEFUL HARDWARE ADDRESS INFORMATION

Item	Description
D5BUG ROM (U12)	\$F000 - F7FF but also "mirrors" such that contents shown in the listing as addresses (\$F400-F7FF) also appear at addresses (\$FC00-FFFF). This mapping is controlled by jumper arrangement J2.
User ROM (U13)	ROM type controlled by J4 jumper arrangement (may be 1K x 8 or 2K x 8; single supply or triple supply; ROM or PROM) Mapping controlled by J3 jumper arrangement may be mapped in any combination of the 1K address areas ... \$E800 - EBFF; \$EC00 - EFFF; \$F800 - FBFF; or \$FC00 - FFFF.
System Scratch RAM	Located at \$E400 - E47F. This RAM is further divided into (3) sections: \$E400 - E418 provided for user's stack \$E419 - E463, D5BUG scratch RAM \$E464 - E47F, D5BUG stack
User RAM (in U5)	\$0000 - 007F inside MC6802 (U5) available for user. Must be disabled by jumper E1 if expansion buffer (U3) is installed.
Optional RAM (U7, U8)	\$E000 - E3FF optional MCM2114 RAMs available for user.
System PIA	<p>\$E484 - E487 which further breaks down to:</p> <p>\$E484 - Data Port A \$E485 - Control Reg A \$E486 - Data Port B \$E487 - Control Reg B</p> <p>Also incomplete address decoding causes "mirroring" which makes this PIA also appear at addresses which meet this requirement: 1110 01XX 0XXX XO XX 4 Regs in PIA where "X's" are don't care. The total number of "images" is (64) with the first image at \$E484 - E487 and the last image at \$E7F8 - E7FB.</p>

7.5 Hardware Address Information (cont'd)

TABLE 7.3. USEFUL HARDWARE ADDRESS INFORMATION (cont'd)

Item	Description
User PIA	<p>\$E480 - E483 which further breaks down to: \$E480 - Data Port A \$E481 - Control Reg A \$E482 - Data Port B \$E483 - Control Reg B</p> <p>Also as with the system PIA above, incomplete Addr. decoding is responsible for "mirroring" at all addresses meeting the requirement: 1110 01XX 1XXX X1 XX or a total of (64) "images" with the first image at \$E480 - E483 and the last image at \$E7FC - E7FF.</p>
ACIA (U33*) *Optional - not used when keypad is present	<p>\$E700, E701 which further breaks down to: \$E700 Control/status register \$E701 Data register</p> <p>Also as with the PIA's above, incomplete address decoding is responsible for "mirroring" at all addresses meeting the requirement: 1110 0111 OXXX XXX X <div style="text-align: right;">2 REGS In ACIA</div> or a total of (64) "images" with the first image at \$E700, E701 and the last image at \$E77E, E77F.</p>
OFF-BOARD	<p>\$0000 - \$DFFF, this 56K address area is assumed to be external to the MEK6802D5 for expansion purposes. To use this address space, install U1, U2, and U3 buffers and E1 (jumper to disable RAM in MC6802, U5).</p>

7.6 D5BUG Listing

The following is the D5BUG Program Listing. It consists of 35 pages. Refer to paragraph 7.7 for a description of this listing.

RESET

```

0001
0002
0003A F000
0004
0005
0006
0007
0008
0009A F000 01
0010A F001 0F
0011A F002 CE E3FF A
0012A F005 08
0013A F006 6F 00 A
0014A F008 8C E487 A
0015A F00B 26 F8 F005
0016A F00D CE E484 A
0017A F010 86 7F A
0018A F012 A7 00 A
0019A F014 86 FF A
0020A F016 A7 02 A
0021A F018 86 06 A
0022A F01A A7 01 A
0023A F01C A7 03 A
0024A F01E CE E418 A
0025A F021 FF E42F A
0026
0027
0028
0029
0030
0031A F024 8E E47E A
0032A F027 86 01 A
0033A F029 B7 E423 A
0034A F02C 7F E43B A
0035A F02F 7F E438 A
0036A F032 7F E41C A
0037A F035 7F E43E A
0038A F038 86 40 A
0039A F03A B7 E41D A
0040A F03D 86 1F A
0041A F03F BD F195 A
0042A F042 CE F0E5 A
0043A F045 FF E419 A
0044A F048 BD F7AE A
0045A F04B 7E F0BB A

                                NAM    RESET
                                OPT    CREF,LLEN=80
                                ORG     $F000
*****
*
* RESET - COLD START ROUTINE
*
*****
RESET  NOP                      SET INTERRUPT MASK
                                SEI
                                LDX    #$E3FF  CLEAR RAM
CLRLOP INX                      .
                                CLR     0,X    .
                                CPX     #$E487 .
                                BNE     CLRLOP .
                                LDX     #$E484 INITIALIZE SYSTEM PIA
                                LDAA    #$7F   .
                                STAA    0,X    .
                                LDAA    #$FF   .
                                STAA    2,X    .
                                LDAA    #$06   .
                                STAA    1,X    .
                                STAA    3,X    .
                                LDX     #$E418 DEFAULT USER STACK
                                STX     USP    .
*****
*
* PROMPT - ROUTINE TO SET UP PROMPT CONDITIONS
*
*****
PROMPT LDS    $STKTOP  INIT SYSTEM STACK
                                LDAA    #1    SET FIRST PASS
                                STAA    ROLPAS .
                                CLR     UPROG  INIT FLAGS
                                CLR     ROIFLG .
                                CLR     KYFLG .
                                CLR     FNCFL .
                                LDAA    #$40   DISPLAY PROMPT
                                STAA    DISBUF .
                                LDAA    #$00011111 .
                                JSR     CLRDS  .
                                LDX     $FUNSEL EXECUTE FUNCTION SELECT
                                STX     MNPTR  .
                                JSR     ENNMI  ENABLE NMI
                                JMP     PUT    & GO

```

KPIO

0048
0049
0050
0051
0052

```
*****
*
* GET - ROUTINE TO READ A KEY
*
*****
```

```
0054A F04E CE E484 A GET LDX #PIA POINT AT PIA
0055A F051 86 FF A LDAA #$FF .
0056A F053 A7 00 A STAA KPCOL,X TO TURN OFF DISPLAYS
0057A F055 86 3F A LDAA #00111111 COL 0, ALL ROWS
0058A F057 A7 02 A LPCOL STAA KPCOL,X STORE INFO TO KEY MATRIX
0059A F059 6D 00 A TST KPCOL,X MSB IS MUX BIT
0060A F05B 2A 06 F063 BPL COLFND BIT-7 LOW MEANS COL FOUND
0061A F05D 8B 40 A ADDA $40 INC COL BITS TO MUX
0062A F05F 24 F6 F057 BCC LPCOL CONTINUE FOR ALL COLS
0063A F061 20 EB F04E BRA GET KEY BOUNCED, START OVER
0064A F063 84 C0 A COLFND ANDA #11000000 MASK TO SAVE ONLY COL
0065A F065 B7 E41B A STAA KEY WILL UPDATE LATER; JUST TEMP SAV
0066A F068 C6 20 A LDAB #00100000 ROW 5
0067A F06A 17 LPROW TBA COPY ROW INFO TO A-REG
0068A F06B BA E41B A ORAA KEY COMBINE WITH COL INFO
0069A F06E A7 02 A STAA KPCOL,X DRIVE KEY MATRIX
0070A F070 6D 00 A TST KPCOL,X MSB LOW = CLOSURE
0071A F072 2A 05 F079 BPL ROWFND
0072A F074 54 LSRB NEXT LOWER ROW BIT
0073A F075 26 F3 F06A BNE LPROW LOOP TILL ALL ROWS TRIED
0074A F077 20 D5 F04E BRA GET KEY BOUNCED; START OVER
0075A F079 4F ROWFND CLRA PREPARE TO FIND BINARY ROW #
0076A F07A 54 LPFND LSRB LOOP BUILDS BINARY ROW #
0077A F07B 25 03 F080 BCS DUNROW WHEN BIT FALLS OFF; A-REG HAS #
0078A F07D 4C INCA
0079A F07E 20 FA F07A BRA LPFND
0080A F080 79 E41B A DUNROW ROL KEY
0081A F083 49 ROLA
0082A F084 79 E41B A ROL KEY
0083A F087 49 ROLA A-REG IS 000RRRCC
0084 * A-REG NOW CONTAINS OFFSET FOR KEY LOOK-UP
0085A F088 6D 00 A CLOP TST KPCOL,X SEE IF KEY STILL DOWN
0086A F08A 2A FC F088 BPL CLOP WAIT TILL LET UP
0087A F08C BD F169 A JSR DLY25 DELAY TO DEBOUNCE
0088A F08F CE F0A3 A LDX #KYTBL POINT AT TOP OF TABLE
0089A F092 BD F183 A JSR ADDAX CALC ADDR OF KEY CODE
0090A F095 A6 00 A LDAA ,X GET KEY CODE
0091A F097 B7 E41B A STAA KEY SAVE KEY VALUE
0092A F09A C6 01 A LDAB #1
0093A F09C F7 E41C A STAB KYFLG INDICATE KEY PENDING
0094A F09F F6 E486 A LDAB PIAROW TO CLEAR NMI
0095A F0A2 39 DIDDLE RTS ** RETURN **
0096 *
0097 * THIS RTS IS USED AS A DO-NOTHING SUB
0098 * SO SYST CAN BE DISABLED EXCEPT DISPLAY
0099 *
```

KPIO

```

0101 *****
0102 *
0103 * KYTBL - KEY VALUE TABLE
0104 *
0105 *****
0106A FOA3 00 A KYTBL FCB $00 '0' KEY
0107A FOA4 0F A FCB $0F 'F'
0108A FOA5 0E A FCB $0E 'E'
0109A FOA6 0D A FCB $0D 'D'
0110A FOA7 01 A FCB $01 '1'
0111A FOA8 02 A FCB $02 '2'
0112A FOA9 03 A FCB $03 '3'
0113A FOAA 0C A FCB $0C 'C'
0114A FOAB 04 A FCB $04 '4'
0115A FOAC 05 A FCB $05 '5'
0116A FOAD 06 A FCB $06 '6'
0117A FOAE 0B A FCB $0B 'B'
0118A FOAF 07 A FCB $07 '7'
0119A FOB0 08 A FCB $08 '8'
0120A FOB1 09 A FCB $09 '9'
0121A FOB2 0A A FCB $0A 'A'
0122A FOB3 84 A FCB $84 'FS' FUNCTION SET
0123A FOB4 85 A FCB $85 'FC' FUNCTION CLEAR
0124A FOB5 86 A FCB $86 'P/L' PUNCH/LOAD
0125A FOB6 87 A FCB $87 'T/B' TRACE/BREAK
0126A FOB7 80 A FCB $80 'MD' MEMORY DISPLAY
0127A FOB8 81 A FCB $81 'EX' ESCAPE
0128A FOB9 82 A FCB $82 'RD' REGISTER DISPLAY
0129A FOBA 83 A FCB $83 'GO' GO

```

KPIO

```

0131 *****
0132 *
0133 * PUT - DISPLAYS DATA IN DISBUF & CALLS THE
0134 * FUNCTIONING SUBROUTINE
0135 *
0136 *****
0137A F0BB C6 20 A PUT LDAB #800100000 INIT DIG ENABLE PATTERN
0138A F0BD CE E41A A LP1P LDX #DISBUF-3 POINT AT DISPLAY BUFFER
0139A F0C0 17 TBA MAKE EXTRA COPY
0140A F0C1 08 LP2P INX POINT AT NXT DIGIT INFO
0141A F0C2 48 ASLA ADD 1 TO 'X' FOR EACH SHIFT
0142A F0C3 24 FC F0C1 BCC LP2P LOOP DEVELOPS DIGIT INFO ADDR
0143A F0C5 A6 00 A LDAA ,X GET SEG INFO
0144A F0C7 43 COMA ANODE DRIVERS ARE GND TRUE
0145A F0C8 B7 E484 A STAA ANOD STORE ANODE INFO TO PIA
0146A F0CB F7 E486 A STAB CATH ENABLE DIGIT CATHODE
0147A F0CE BD F171 A JSR DLY1 ON FOR 1 MILLISECOND
0148A F0D1 86 FF A LDAA #811111111 1'S TURN OFF SEGS
0149A F0D3 B7 E484 A STAA ANOD TURN OFF ALL SEGS
0150A F0D6 B7 E486 A STAA CATH ENABLE ALL KPD ROWS
0151A F0D9 37 PSHB HAS ROTATING DIGIT ENABLE
0152A F0DA FE E419 A LDX MNPTR GET ADDRESS OF ACTIVE MAIN PROG
0153A F0DD AD 00 A JSR ,X EXECUTE IT
0154 *****
0155 ***** SEE MANUAL
0156 *****
0157A F0DF 33 PULB RECOVER DIGIT ENABLE
0158A F0E0 54 LSRB NEXT DIGIT
0159A F0E1 26 DA F0BD BNE LP1P NOT THRU WHOLE CYCLE
0160A F0E3 20 D6 F0BB BRA PUT PAST LAST DIGIT
0161 *

```

FUNSEL

0164
0165
0166
0167
0168
0169A FOE5 7D E41C A
0170A FOE8 26 01 FOEB
0171A FOEA 39
0172
0173A FOEB BD F1EF A
0174A FOEE 2B 15 F105
0175A FOF0 7D E43E A
0176A FOF3 26 0B F100
0177A FOF5 BD F1CC A
0178A FOF8 BD F120 A
0179A FOFB 86 03 A
0180A FOFD 7E F195 A
0181
0182A F100 FE E43F A
0183A F103 20 03 F108
0184
0185A F105 CE F110 A
0186A F108 48
0187A F109 BD F183 A
0188A F10C EE 00 A
0189A F10E 6E 00 A
0190
0191
0192A F110 F1F6 A
0193A F112 F024 A
0194A F114 F2CA A
0195A F116 F6F3 A
0196A F118 F4C5 A
0197A F11A F4D1 A
0198A F11C F4D7 A
0199A F11E F388 A
0200
0201

*
* FUNSEL - ROUTINE TO SELECT A FUNCTION FROM A KEY INPUT
*

FUNSEL TST KYFLG KEY PENDING ?
BNE KEYNOW YES,TEST IT
RTS ** RETURN ** NO KEY PENDING
*
KEYNOW JSR RDKEY GET & ACKNOWLEDGE KEY
BMI FUNKY IF FUNCTION KEY
TST FNCFL
BNE UFNK
JSR ROLL4 # ENTRY SO ROLL IT IN
JSR DYSCOD CONVERT TO 7-SEG
LDAA #00000011
JMP CLRDS BLANK LAST 2 DIGITS
*
UFNK LDX FNCPNT POINT AT USER FUNCTION TABLE
BRA HASH .
*
FUNKY LDX #SYSFNC POINT AT SYSTEM FUNCTION TBL
HASH ASLA 2 BYTES PER ENTRY
JSR ADDAX DEVELOP POINTER
LDX ,X GET JMP ADDR
JMP ,X ** GO THERE **
*
*
SYSFNC FDB MEMBEG 'MD'
FDB PROMPT 'EX'
FDB REGBEG 'RD'
FDB GO 'GO'
FDB FSET 'FS'
FDB FCLR 'FC'
FDB TAPBEG 'P/L'
FDB BRKBEG 'T/B'
*

MISC

```

0204 *****
0205 *
0206 * MISC - MISC ROUTINES
0207 *
0208 *****
0209 * DECODE HEX TO 7-SEGMENT
0210 *
0211A F120 36      DYSCOD PSHA      SAVE REGS
0212A F121 37      PSHB
0213A F122 FF E426 A      STX      XSAV1
0214A F125 CE E42C A      LDX      #HEXBUF POINT AT HEX INFO
0215A F128 A6 00      A LP01 LDAA      ,X      GET HEX BYTE
0216A F12A 16      TAB      MAKE EXTRA COPY
0217A F12B 54      LSRB      RIGHT JUSTIFY HIGH NIBBLE
0218A F12C 54      LSRB
0219A F12D 54      LSRB
0220A F12E 54      LSRB      HIGH ORDER DIGIT IN B-REG
0221A F12F 84 0F      A      ANDA      #$0F      LOW ORDER DIGIT IN A-REG
0222A F131 37      PSHB      SAVE ON STACK
0223A F132 36      PSHA
0224A F133 08      INX      NEXT HEX BYTE
0225A F134 8C E42F A      CPX      #HEXBUF+3 DONE ?
0226A F137 26 EF F128 BNE      LP01      LOOP 3 TIMES
0227A F139 CE E422 A      LDX      #DISBUF+5 LAST DISPLAY BUFFER DIGIT
0228A F13C C6 05      A      LDAB      #5      LOOP INDEX
0229A F13E FF E428 A LP02 STX      XTMP1      SAVE TEMPORARILY
0230A F141 CE F159 A      LDX      #DYSTBL POINT AT LOOK-UP TABLE
0231A F144 32      PULA      GET A HEX DIGIT TO CONVERT
0232A F145 BD F183 A      JSR      ADDAX      POINT AT 7-SEG EQUIV
0233A F148 A6 00      A      LDAA      ,X      GET IT
0234A F14A FE E428 A      LDX      XTMP1      RECOVER POINTER TO DISP BUFFER
0235A F14D A7 00      A      STAA      ,X      STORE CONVERTED DIG
0236A F14F 09      DEX      NEXT DISPLAY POS
0237A F150 5A      DECB      LOOP INDEX
0238A F151 2A EB F13E BPL      LP02      CONTINUE FOR 6 DIGITS
0239A F153 FE E426 A      LDX      XSAV1      RECOVER ENTRY STATUS
0240A F156 33      PULB
0241A F157 32      PULA
0242A F158 39      RTS      ** RETURN **
0243 *
0244 *
0245A F159 3F      A DYSTBL FCB      %00111111 '0'
0246A F15A 06      A      FCB      %00000110 '1'
0247A F15B 5B      A      FCB      %01011011 '2'
0248A F15C 4F      A      FCB      %01001111 '3'
0249A F15D 66      A      FCB      %01100110 '4'
0250A F15E 6D      A      FCB      %01101101 '5'
0251A F15F 7D      A      FCB      %01111101 '6'
0252A F160 07      A      FCB      %00000111 '7'
0253A F161 7F      A      FCB      %01111111 '8'
0254A F162 67      A      FCB      %01100111 '9'
0255A F163 77      A      FCB      %01110111 'A'
0256A F164 7C      A      FCB      %01111100 'B'
0257A F165 39      A      FCB      %00111001 'C'
0258A F166 5E      A      FCB      %01011110 'D'
0259A F167 79      A      FCB      %01111001 'E'
0260A F168 71      A      FCB      %01110001 'F'

```

MISC

```

0262      *
0263      * DELAY SUBS
0264      *
0265A F169 FF E424 A DLY25 STX XSAVD SAVE X ENTRY VALUE
0266A F16C CE 0AEA A LDX #2794 25 MS ENTRY POINT
0267A F16F 20 0B F17C BRA DLYLP
0268A F171 FF E424 A DLY1 STX XSAVD SAVE ENTRY VAL
0269A F174 CE 006D A LDX #109 1 MS COUNT
0270A F177 20 03 F17C BRA DLYLP
0271A F179 FF E424 A DLYX STX XSAVD REQUIRED FOR SIMILARITY TO DLY1/25
0272A F17C 09 DLYLP DEX
0273A F17D 26 FD F17C BNE DLYLP LOOP TILL X=0
0274A F17F FE E424 A LDX XSAVD RECOVER ENTRY VALUE
0275A F182 39 RTS ** RETURN **
0276      *
0277      * SUBROUTINE TO ADD X=X+A
0278      *
0279A F183 FF E424 A ADDAX STX XSAVD TO ALLOW CALCS
0280A F186 BB E425 A ADDA XSAVD+1 ADD LOW BYTES
0281A F189 B7 E425 A STAA XSAVD+1 UPDATE
0282A F18C 24 03 F191 BCC ARND IF NO CARRY; YOU'RE DONE
0283A F18E 7C E424 A INC XSAVD ADD CARRY TO HIGH BYTE
0284A F191 FE E424 A ARND LDX XSAVD RESULT TO X-REG
0285A F194 39 RTS ** RETURN **
0286      *
0287      * CLEAR DISPLAY PER A-REG
0288      *
0289A F195 FF E426 A CLRDS STX XSAV1 SAVE ENTRY VALUE
0290A F198 CE E422 A LDX #DISBUF+5 RIGHTMOST DIGIT
0291A F19B 44 CLRLP LSRA
0292A F19C 24 02 F1A0 BCC ARNCLR IF BIT IN A-REG NOT SET
0293A F19E 6F 00 A CLR ,X
0294A F1A0 09 ARNCLR DEX NEXT DISPLAY
0295A F1A1 8C E41C A CPX #DISBUF-1 DONE ?
0296A F1A4 26 F5 F19B BNE CLRLP CONTINUE 6 TIMES
0297A F1A6 FE E426 A LDX XSAV1 RECOVER ENTRY VALUE
0298A F1A9 39 RTS ** RETURN **
0299      *
0300A F1AA FF E426 A ROLL2 STX XSAV1 SAVE ENTRY VALUE
0301A F1AD FE E42C A LDX HEXBUF ADDR TO ROLL
0302A F1B0 7D E423 A TST ROLPAS FIRST PASS ?
0303A F1B3 27 07 F1BC BEQ ARNCL2
0304A F1B5 7F E423 A CLR ROLPAS THIS WAS PASS 1
0305A F1B8 6F 00 A CLR ,X CLEAR LOC ON FIRST PASS
0306A F1BA 20 08 F1C4 BRA R2OUT
0307A F1BC 68 00 A ARNCL2 ASL ,X
0308A F1BE 68 00 A ASL ,X
0309A F1C0 68 00 A ASL ,X
0310A F1C2 68 00 A ASL ,X SHIFT ROLL BYTE 4 PLACES
0311A F1C4 AA 00 A R2OUT ORAA ,X COMBINE NEW DATA
0312A F1C6 A7 00 A STAA ,X UPDATE LOC
0313A F1C8 FE E426 A LDX XSAV1 RECOVER ENTRY VAL
0314A F1CB 39 RTS ** RETURN **

```

MISC

```

0316      *
0317      * ROLL 4 HEX INTO HEXBUF
0318      *
0319A F1CC 37      ROLL4 PSHB      SAVE ENTRY VALUES
0320A F1CD 7D E423 A      TST      ROLPAS      PASS 1 ?
0321A F1D0 27 0B F1DD      BEQ      ARNCL4      NO,CONTINUE
0322A F1D2 7F E423 A      CLR      ROLPAS      YES,CLEAR FIRST PASS FLAG &
0323A F1D5 7F E42C A      CLR      HEXBUF      CLR FIRST 4 DIGITS ON FIRST PASS
0324A F1D8 B7 E42D A      STAA     HEXBUF+1    THEN PUT NEW DATA IN 4TH
0325A F1DB 20 10 F1ED      BRA      R4OUT      .
0326A F1DD 48      ARNCL4 ASLA      LEFT JUSTIFY NEW DIGIT
0327A F1DE 48      ASLA      .
0328A F1DF 48      ASLA      .
0329A F1E0 48      ASLA      .
0330A F1E1 C6 03 A      LDAB      #3      LOOP INDEX
0331A F1E3 49      RO4LP      ROLA      ROLLA INTO HEXBUF
0332A F1E4 79 E42D A      ROL      HEXBUF+1    .
0333A F1E7 79 E42C A      ROL      HEXBUF      .
0334A F1EA 5A      DECB      .
0335A F1EB 2A F6 F1E3      BPL      RO4LP      .
0336A F1ED 33      R4OUT      PULB      RECOVER B-REG
0337A F1EE 39      RTS      ** RETURN **
0338      *
0339A F1EF 7F E41C A      RDKEY     CLR      KYFLG      READ & ACKNOWLEDGE KEY
0340A F1F2 B6 E41B A      LDAA     KEY      .
0341A F1F5 39      RTS      .

```


MEMCH

```

0344 *****
0345 *
0346 * MEMCH - MEMORY CHANGE/DISPLAY/OFFSET ROUTINE
0347 *
0348 *****
0349A F1F6 CE F205 A MEMBEG LDX #MEMCH
0350A F1F9 FF E419 A STX MNPTR INIT MAIN POINTER
0351A F1FC 7F E43E A CLR FNCFL SET FUNCTION FLAG TO ZERO
0352A F1FF FE E42C A LDX HEXBUF POINT AT ADDR TO DISPLAY
0353A F202 7E F2BA A JMP NEWMEM EXIT TO UPDATE DISPLAY
0354 *
0355A F205 7D E41C A MEMCH TST KYFLG SEE IF ANY KEY PENDING
0356A F208 26 01 F20B BNE MEMNOW
0357A F20A 39 RTS ** RETURN **
0358 *
0359A F20B BD F1EF A MEMNOW JSR RDKEY GET & ACKNOWLEDGE KEY
0360A F20E FE E42C A LDX HEXBUF SAVES STEPS LATER
0361A F211 F6 E43E A LDAB FNCFL SEE IF IN OFFSET MODE
0362A F214 27 77 F28D BEQ NORMAL (NOT OFFSET MODE)
0363A F216 2B 53 F26B BMI CALDUN IF OFFSET CALC FINISHED
0364A F218 4D TSTA CHECK KEY
0365A F219 2B 0D F228 BMI OFFUN IF FUNCTION KEY
0366A F21B BD F1CC A JSR ROLL4 ENTER NUMBER KEY
0367A F21E BD F120 A OFFOUT JSR DYSCOD CONVERT TO 7-SEG
0368A F221 CE 0077 A OFFEND LDX #0077 "A"
0369A F224 FF E421 A STX DISBUF+4 STORE TO LAST DIGITS
0370A F227 39 OFFRET RTS ** RETURN **
0371 *
0372A F228 81 83 A OFFUN CMPA #83 'GO' ?
0373A F22A 26 FB F227 BNE OFFRET IF NOT; EXIT
0374A F22C FE E42C A LDX HEXBUF GET DESTINATION OF BRANCH
0375A F22F 09 DEX ADJ INSTEAD OF ADJ'ING THE SOURCE
0376A F230 FF E42C A STX HEXBUF UPDATE
0377A F233 B6 E42D A LDAA HEXBUF+1 LOW BYTE OF DESTINATION
0378A F236 F6 E42C A LDAB HEXBUF HI BYTE
0379A F239 B0 E42B A SUBA MEMSAV+1 SUBTRACT LOW BYTES
0380A F23C F2 E42A A SBCB MEMSAV SUBTRACT W/ CARRY
0381A F23F 4D TSTA CHECH POLARITY OF LOW ORDER RESULT
0382A F240 2A 01 F243 BPL ARNINC IF LO POS DON'T INC HI
0383A F242 5C INCB IF LOW WAS NEG INC HI $FF - $00
0384A F243 5D ARNINC TSTB IF B NOW ZERO; OFFSET IS IN RANGE
0385A F244 26 11 F257 BNE BADOFF IF NOT; TOO FAR
0386A F246 B7 E42E A STAA HEXBUF+2 SAVE RESULT
0387A F249 BD F120 A JSR DYSCOD CONVERT TO 7-SEG
0388A F24C 86 3C A LDAA #00111100 CLEAR FIRST 4 DISPLAYS
0389A F24E BD F195 A JSR CLRDS
0390A F251 86 80 A LDAA #80
0391A F253 B7 E43E A STAA FNCFL INDICATE CALC DONE; & OK
0392A F256 39 RTS ** RETURN **
0393 *
0394A F257 CE BAD0 A BADOFF LDX #BAD0
0395A F25A FF E42C A STX HEXBUF
0396A F25D BD F120 A JSR DYSCOD WRITE "BAD" IN FIRST 3 DISPLAYS
0397A F260 86 07 A LDAA #00000111
0398A F262 BD F195 A JSR CLRDS CLEAR UNUSED DIGITS
0399A F265 86 FF A LDAA $FF
0400A F267 B7 E43E A STAA FNCFL INDICATE OFFSET NOT VALID
0401A F26A 39 RTS ** RETURN **

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MEMCH

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0402
0403A F26B 5C          * CALDUN INCB          IF IT WAS $FF IT'S NOW 0
0404A F26C 27 13 F281 BEQ      BADCAL          OFFSET WAS BAD
0405A F26E FE E42A A    LDX      MEMSAV         RECOVER MEM ADDR
0406A F271 81 85      A    CMPA    #$85         FUNCTION CLEAR KEY ?
0407A F273 27 13 F288 BEQ      MEMBAK         YES,DONT SAVE OFFSET
0408A F275 81 83      A    CMPA    #$83         'GO' ?
0409A F277 26 AE F227 BNE      OFFRET        'GO' IS ONLY VALID KEY HERE
0410A F279 B6 E42E A    LDAA     HEXBUF+2      GET CALC'D OFFSET
0411A F27C A7 00      A    STAA    ,X          STORE TO MEM
0412A F27E 08          INX          ADV TO NEXT MEM ADDR
0413A F27F 20 07 F288 BRA      MEMBAK         BACK TO MEM CHANGE
0414
0415A F281 81 80      A BADCAL CMPA    #$80         'MD' ?
0416A F283 26 A2 F227 BNE      OFFRET        'MD' IS THE ONLY VALID KEY HERE
0417A F285 FE E42A A    LDX      MEMSAV         RECOVER MEM ADDRESS
0418A F288 7F E43E A MEMBAK CLR      FNCFL       SIGNAL NOT IN OFFSET MODE
0419A F28B 20 2D F2BA BRA      NEWMEM        RE-ENTER MEM CHANGE
0420
0421A F28D 4D          * NORMAL TSTA          SET COND CODES
0422A F28E 2A 25 F2B5 BPL      NUM           IF NUMBER KEY
0423A F290 81 80      A    CMPA    #$80         'MD' ?
0424A F292 26 03 F297 BNE      NXM1          NO,CHECK FOR "GO"
0425A F294 09          DEX           YES,BACK UP
0426A F295 20 23 F2BA BRA      NEWMEM        .
0427
0428A F297 81 83      A NXM1  CMPA    #$83         'GO' ?
0429A F299 26 03 F29E BNE      NXM2          NO,CHECK FOR "FS"
0430A F29B 08          INX           YES,ADVANCE
0431A F29C 20 1C F2BA BRA      NEWMEM        .
0432A F29E 81 84      A NXM2  CMPA    #$84         'FS' ?
0433A F2A0 26 1D F2BF BNE      MEMOUT        NO MORE VALID KEYS
0434A F2A2 86 3F      A    LDAA     #$00111111
0435A F2A4 BD F195 A    JSR      CLRDS         .
0436A F2A7 86 01      A    LDAA     #1          .
0437A F2A9 B7 E43E A    STAA     FNCFL       SET OFFSET MODE
0438A F2AC B7 E423 A    STAA     ROLPAS      SET FIRST PASS
0439A F2AF FF E42A A    STX      MEMSAV      SAVE MEM CHG POINTER
0440A F2B2 7E F221 A    JMP      OFFEND
0441
0442A F2B5 BD F1AA A NUM  JSR      ROLL2        ENTER NEW DIGIT
0443A F2B8 20 05 F2BF BRA      MEMOUT       DON'T SET FIRST PASS
0444
0445A F2BA 86 01      A NEWMEM LDAA     #1
0446A F2BC B7 E423 A    STAA     ROLPAS      SET FIRST PASS FLAG
0447
0448A F2BF A6 00      A MEMOUT LDAA     ,X      GET DATA TO DISPLAY
0449A F2C1 B7 E42E A    STAA     HEXBUF+2     UPDATE HEX BUFFER
0450A F2C4 FF E42C A    STX      HEXBUF      UPDATE ADDR
0451A F2C7 7E F120 A    JMP      DYSCOD      CONV TO 7-SEG
0452

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REGDIS

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0456 *****
0457 *
0458 * REGDIS - REGISTER DISPLAY/CHANGE ROUTINE
0459 *
0460 *****
0461 *
0462A F2CA 7D E43E A REGBEG TST FNCFL SEE IF IN VERIFY
0463A F2CD 27 06 F2D5 BEQ NOTVRF
0464A F2CF 7F E43E A CLR FNCFL SIGNAL VERIFY
0465A F2D2 7E F4DC A JMP LDTAP GO VERIFY TAPE
0466A F2D5 CE F2EE A NOTVRF LDX #REGDIS
0467A F2D8 FF E419 A STX MNPTR INIT MAIN POINTER
0468A F2DB CE F0BB A LDX #PUT SET SO RTS...
0469A F2DE FF E47D A STX STKTOP-1 WILL BE TO PUT
0470A F2E1 8E E47C A LDS #STKTOP-2 INIT STACKPOINTER
0471A F2E4 7F E441 A CLR REGNO INIT REG # = UPC
0472A F2E7 86 01 A LDAA #1
0473A F2E9 B7 E423 A STAA ROLPAS INDICATE FIRST PASS
0474A F2EC 20 40 F32E BRA REGOUT TO UPDATE DISPLAY
0475 *
0476A F2EE 7D E41C A REGDIS TST KYFLG SEE IF ANY KEY PENDING
0477A F2F1 26 01 F2F4 BNE REGNOW
0478A F2F3 39 RTS ** RETURN ** NO KEY
0479 *
0480A F2F4 BD F1EF A REGNOW JSR RDKEY GET & ACKNOWLEDGE KEY
0481A F2F7 2B 05 F2FE BMI REGFNC IF FUNCTION KEY
0482A F2F9 BD F1CC A JSR ROLL4
0483A F2FC 20 30 F32E BRA REGOUT UPDATE DISPLAY & EXIT
0484 *
0485A F2FE 81 80 A REGFNC CMPA #$80 'MD' ?
0486A F300 26 0D F30F BNE NXR1
0487A F302 B6 E441 A LDAA REGNO
0488A F305 4A DECA
0489A F306 2A 02 F30A BPL ARNR1
0490A F308 86 05 A LDAA #5
0491A F30A B7 E441 A ARNR1 STAA REGNO WRAP AROUND
0492A F30D 20 10 F31F BRA NEWREG UPDATE
0493 * SET UP NEW REG ON EXIT
0494A F30F 81 83 A NXR1 CMPA #$83 'GO'
0495A F311 26 11 F324 BNE RUNONE IGNORE INVALID ENTRY
0496A F313 B6 E441 A LDAA REGNO
0497A F316 4C INCA
0498A F317 81 06 A CMPA #6 PAST ?
0499A F319 26 01 F31C BNE ARNR2
0500A F31B 4F CLRA
0501A F31C B7 E441 A ARNR2 STAA REGNO WRAP AROUND
0502A F31F 86 01 A NEWREG LDAA #1 UPDATE
0503A F321 B7 E423 A STAA ROLPAS
0504 *
0505A F324 81 87 A RUNONE CMPA #$87 T/B KEY ?
0506A F326 26 06 F32E BNE REGOUT NO, RETURN
0507A F328 CE F2CA A LDX #REGBEG YES, SET UP RETURN ADDR
0508A F32B 7E F701 A JMP ROI .
0509 *
0510A F32E B6 E441 A REGOUT LDAA REGNO
0511A F331 48 ASLA
0512A F332 48 ASLA 4-BYTES PER BLOCK ENTRY
0513A F333 CE F370 A LDX #REGTBL TOP OF INFO TABLE

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REGDIS

0514A	F336	BD	F183	A	JSR	ADDAX	POINT AT TABLE ENTRY
0515A	F339	A6	03	A	LDAA	3,X	GET 7-SEG INFO
0516A	F33B	36			PSHA		SAVE ON STACK
0517A	F33C	A6	02	A	LDAA	2,X	.
0518A	F33E	36			PSHA		.
0519A	F33F	EE	00	A	LDX	,X	GET ADDR OF DESIRED REG
0520A	F341	7D	E423	A	TST	ROLPAS	SEE IF NEW REG
0521A	F344	27	0A	F350	BEQ	NOTNEW	
0522A	F346	A6	00	A	LDAA	,X	STORE CURRENT VAL TO DISPLAY
0523A	F348	B7	E42C	A	STAA	HEXBUF	.
0524A	F34B	A6	01	A	LDAA	1,X	.
0525A	F34D	B7	E42D	A	STAA	HEXBUF+1	.
0526				*			
0527A	F350	BD	F120	A	NOTNEW JSR	DYSCOD	TO CONVERT TO 7-SEG
0528A	F353	32			PULA		RECOVER DISPLAY CODES
0529A	F354	B7	E421	A	STAA	DISBUF+4	& STORE TO DISP BUFFER
0530A	F357	32			PULA		.
0531A	F358	B7	E422	A	STAA	DISBUF+5	.
0532A	F35B	2A	08	F365	BPL	ARNR3	.
0533A	F35D	7F	E41D	A	CLR	DISBUF	CLEAR UNUSED DISPLAYS
0534A	F360	7F	E41E	A	CLR	DISBUF+1	.
0535A	F363	20	05	F36A	BRA	ONLY1	.
0536A	F365	B6	E42C	A	ARNR3 LDAA	HEXBUF	UPDATE HIGH OF PSEUDO REG
0537A	F368	A7	00	A	STAA	,X	.
0538A	F36A	B6	E42D	A	ONLY1 LDAA	HEXBUF+1	.
0539A	F36D	A7	01	A	STAA	1,X	UPDATE LOW BYTE
0540A	F36F	39			RTS		** RETURN **
0541				*			
0542				*			
0543A	F370		E436	A	REGTBL FDB	UPC	
0544A	F372		73	A	FCB	%011110011,%00111001	
0545				*			
0546A	F374		E432	A	FDB	UA-1	
0547A	F376		00	A	FCB	%00000000,%11110111	
0548				*			
0549A	F378		E431	A	FDB	UB-1	
0550A	F37A		00	A	FCB	%00000000,%11111100	
0551				*			
0552A	F37C		E434	A	FDB	UX	
0553A	F37E		06	A	FCB	%00000110,%01011110	
0554				*			
0555A	F380		E42F	A	FDB	USP	
0556A	F382		6D	A	FCB	%01101101,%01110011	
0557				*			
0558A	F384		E430	A	FDB	UCC-1	
0559A	F386		39	A	FCB	%00111001,%10111001	
0560				*			

BRKBEG

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0564 *****
0565 *
0566 * BRKBEG - BREAKPOINT EDITOR
0567 *
0568 *****
0569A F388 7D E43E A BRKBEG TST FNCFL FUNCTION FLAG SET ?
0570A F38B 26 01 F38E BNE BRKEDT YES,EDIT BREAKPIONTS
0571A F38D 39 RTS NO,TAKE NO ACTION
0572A F38E CE F39C A BRKEDT LDX #BRKPNT SET MNPTR WITH BREAKPOINT ROUTINE
0573A F391 FF E419 A STX MNPTR .
0574A F394 86 01 A LDAA #$01 SET UP FOR ADDR INPUT
0575A F396 B7 E423 A STAA ROLPAS .
0576A F399 7E F3C0 A JMP DISBRK DISPLAY NEXT BKPT
0577A F39C 7D E41C A BRKPNT TST KYFLG KEY PENDING ?
0578A F39F 26 01 F3A2 BNE BRKTST YES,DECODE KEY ?
0579A F3A1 39 RTS NO,RETURN TO PUT
0580A F3A2 BD F1EF A BRKTST JSR RDKEY GET & ACKNOWLEDGE KEY
0581A F3A5 81 0F A CMPA #$0F HEX ?
0582A F3A7 22 06 F3AF BHI NOTHEX NO,CHECK FOR FUNCTION
0583A F3A9 BD F1CC A JSR ROLL4 YES, ROLL INTO HEXBUF
0584A F3AC 7E F120 A JMP DYSCOD DISPLAY & RETURN TO PUT
0585A F3AF 81 84 A NOTHEX CMPA #$84 FS KEY ?
0586A F3B1 26 02 F3B5 BNE CKFC NO,TRY FC
0587A F3B3 20 3C F3F1 BRA BKTOTB YES,ENTER AS BKPT & RETURN
0588A F3B5 81 85 A CKFC CMPA #$85 FC KEY ?
0589A F3B7 26 03 F3BC BNE CKGO NO,CHECK FOR GO
0590A F3B9 7E F42E A JMP BKFBMTB YES,REMOVE A BKPT
0591A F3BC 81 83 A CKGO CMPA #$83 GO KEY ?
0592A F3BE 26 30 F3F0 BNE DISDUN YES,DISPLAY NEXT BKPT & RETURN
0593 *
0594 * DISBRK - DISPLAY NEXT BREAKPOINT
0595 *
0596A F3C0 B6 E444 A DISBRK LDAA BRKNO GET # INTO HEXBUF
0597A F3C3 B7 E42E A STAA HEXBUF+2 ANY BREAKPOINTS ?
0598A F3C6 27 1B F3E3 BEQ BACK NO,RETURN
0599A F3C8 FE E442 A LDX BKPNTR YES,DISPLAY NEXT ONE
0600A F3CB 08 BKLOOP INX .
0601A F3CC 08 INX .
0602A F3CD 08 INX .
0603A F3CE 08 INX .
0604A F3CF 8C E459 A CPX #BRKEND END OF TAB
0605A F3D2 26 03 F3D7 BNE NOTEND NO,GO TEST FOR BKPT
0606A F3D4 CE E445 A LDX #BRKTAB YES,WRAP AROUND
0607A F3D7 6D 03 A NOTEND TST 3,X BREAKPOINT ?
0608A F3D9 27 F0 F3CB BEQ BKLOOP NO,TRY NEXT LOC
0609A F3DB FF E442 A STX BKPNTR YES,MOVE POINTER
0610A F3DE EE 00 A LDX 0,X GET BKPT ADDR
0611A F3E0 FF E42C A STX HEXBUF & DISPLAY IT
0612A F3E3 BD F120 A BACK JSR DYSCOD .
0613A F3E6 7D E444 A TST BRKNO ANY BREAKPOINTS ?
0614A F3E9 26 05 F3F0 BNE DISDUN YES,RETURN
0615A F3EB 86 FE A LDAA #$FE MASK ALL BUT LSD
0616A F3ED BD F195 A JSR CLRDS .
0617A F3F0 39 DISDUN RTS RETURN TO PUT

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BRKBEG

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0619
0620
0621
0622
0623A F3F1 BD F4A0 A BKTOTB JSR FND BRK BREAKPOINT EXIST ?
0624A F3F4 25 32 F428 BCS FULL YES, RETURN
0625A F3F6 8D 46 F43E BSR BKNO FIND OPEN SPACE
0626A F3F8 B6 E444 A LDAA BRKNO GET # OF BREAKPOINTS
0627A F3FB 81 05 A CMPA #$05 FULL ?
0628A F3FD 2C 29 F428 BGE FULL YES
0629
0630A F3FF FE E42C A * CHECK FOR RAM LDX HEXBUF TEST FOR RAM
0631A F402 A6 00 A LDAA 0,X .
0632A F404 43 COMA .
0633A F405 63 00 A COM 0,X .
0634A F407 A1 00 A CMPA 0,X RAM ?
0635A F409 26 1D F428 BNE FULL NO , RETURN
0636A F40B 43 COMA YES, RESTORE DATA
0637A F40C A7 00 A STAA 0,X .
0638
0639A F40E FE E442 A * ENTER BKPT INTO TABLE LDX BKPNTN POINT INTO BREAKPOINT TAB
0640A F411 A7 02 A STAA 2,X SAV OPCODE
0641A F413 B6 E42C A LDAA HEXBUF GET OP CODE ADDR
0642A F416 F6 E42D A LDAB HEXBUF+1 .
0643A F419 A7 00 A STAA 0,X INSERT BREAKPOINT
0644A F41B E7 01 A STAB 1,X .
0645A F41D 7C E444 A INC BRKNO COUNT BREAKPOINT
0646A F420 6C 03 A INC 3,X FLAG BRAKPOINT
0647A F422 7C E42E A INC HEXBUF+2 UPDATE BKPT NO.
0648A F425 BD F120 A JSR DYSCOD .
0649A F428 86 01 A FULL LDAA #$01 RESET ROLPAS
0650A F42A B7 E423 A STAA ROLPAS .
0651A F42D 39 RTS & RETURN
0652
0653
0654
0655
0656A F42E 8D 70 F4A0 BKFMTB BSR FND BRK BKPT (DISBUF) IN TABLE ?
0657A F430 24 8E F3C0 BCC DISBRK NO , RETURN
0658A F432 FE E442 A LDX BKPNTN YES , GET ITS ADDR
0659A F435 6F 03 A CLR 3,X & REMOVE IT.
0660A F437 6F 02 A CLR 2,X REMOVE OP CODE
0661A F439 7A E444 A DEC BKNO UPDATE COUNT
0662A F43C 20 82 F3C0 BRA DISBRK DISPLAY BKPT & RETURN
0663
0664
0665
0666
0667A F43E 7F E444 A BKNO CLR BKNO
0668A F441 CE E445 A LDX #BRKTAB
0669A F444 6D 03 A BKLOP TST 3,X BREAKPOINT HERE ?
0670A F446 27 05 F44D BEQ NEXT1 NO, TRY NEXT ENTRY
0671A F448 7C E444 A INC BKNO YES, COUNT IT
0672A F44B 20 03 F450 BRA ISBKPT SO DONT SAVE ADDR
0673A F44D FF E442 A NEXT1 STX BKPNTN & SAVE ADDR
0674A F450 08 ISBKPT INX POINT TO NEXT ENTRY
0675A F451 08 INX .
0676A F452 08 INX .

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BRKBEG

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0677A F453 08          INX          .
0678A F454 8C E459 A   CPX      #BRKEND  DONE ?
0679A F457 26 EB F444  BNE      BKLOP   NO,CONTINUE
0680A F459 86 01      A   LDAA     #$01   RESET ROLPAS
0681A F45B B7 E423 A   STAA     ROLPAS   .
0682A F45E 39          RTS          YES
0683          *****
0684          *
0685          * INBKS - INSERT BREAKPOINTS FROM TABLE TO MEM
0686          *
0687          *****
0688A F45F 7D E444 A   INBKS  TST      BRKNO   BREAKPOINTS ?
0689A F462 27 20 F484  BEQ      NOBPT   NO,RETURN
0690A F464 CE E445 A   LD      #BRKTAB YES,INSTALL'EM
0691A F467 6D 03      A   CKBKPT TST     3,X   BREAKPOINT ?
0692A F469 27 10 F47B  BEQ      NEXT2   NO,TRY NEXT ENTRY
0693          * INSTALL THE BREAKPOINT
0694A F46B FF E442 A   STX      BKPNTN  SAVE X
0695A F46E 86 3F      A   LDAA     #$3F   SWI
0696A F470 EE 00      A   LD      0,X   GET ADDR
0697A F472 E6 00      A   LDAB    0,X   GET OP CODE
0698A F474 A7 00      A   STAA     0,X   STORE SWI
0699A F476 FE E442 A   LD      BKPNTN  RESTORE X
0700A F479 E7 02      A   STAB     2,X   SAVE OPCODE
0701          * NEXT ENTRY
0702A F47B 08          NEXT2 INX          .
0703A F47C 08          INX          .
0704A F47D 08          INX          .
0705A F47E 08          INX          .
0706A F47F 8C E459 A   CPX      #BRKEND  DONE ?
0707A F482 26 E3 F467  BNE      CKBKPT  NO,CONTINUE
0708A F484 39          NOBPT  RTS
0709          *****
0710          *
0711          * OUTBKS - REMOVE BREAKPOINTS FROM MEM
0712          *
0713          *****
0714A F485 CE E445 A   OUTBKS LD      #BRKTAB  POINT TO BREAKPOINT TAB
0715A F488 A6 02      A   REMOV1 LDAA   2,X   OP CODE ?
0716A F48A 27 0A F496  BEQ      NEXT3   NO,TRY NEXT ENTRY
0717          * REMOVE BREAKPOINT FROM RAM
0718A F48C FF E442 A   STX      BKPNTN  SAVE X
0719A F48F EE 00      A   LD      0,X   GET MEM ADDR
0720A F491 A7 00      A   STAA     0,X   INSERT OPCODE
0721A F493 FE E442 A   LD      BKPNTN  RESTORE X
0722          * NEXT ENTRY
0723A F496 08          NEXT3 INX          .
0724A F497 08          INX          .
0725A F498 08          INX          .
0726A F499 08          INX          .
0727A F49A 8C E459 A   CPX      #BRKEND  DONE ?
0728A F49D 26 E9 F488  BNE      REMOV1  NO,CONTINUE
0729A F49F 39          RTS          YES,RETURN

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BRKBEG

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0731      *
0732      * FDBRK - FIND BREAKPOINT (HEXBUF) IN BRKTAB
0733      * BKPNTN POINTS AT BREAKPOINT & CARRY
0734      * IS SET IF BREAKPOINT EXISTS, ELSE C IS ="0"
0735      *
0736A F4A0 B6 E42C A FNDBRK LDAA HEXBUF BREAKPOINT MSB
0737A F4A3 F6 E42D A LDAB HEXBUF+1 BREAKPOINT LSB
0738A F4A6 CE E445 A LDX #BRKTAB BREAKPOINT TAB
0739A F4A9 A1 00 A BRKLOP CMPA 0,X MATCH ?
0740A F4AB 27 0B F4B8 BEQ CKLSB YES
0741A F4AD 08 NEXT INX NO POINT TO NEXT
0742A F4AE 08 INX .
0743A F4AF 08 INX .
0744A F4B0 08 INX .
0745A F4B1 8C E459 A CPX #BRKEND DONE ?
0746A F4B4 26 F3 F4A9 BNE BRKLOP NO,CONTINUE
0747A F4B6 0C CLC YES,BUT NO BKPT
0748A F4B7 39 RTS
0749A F4B8 E1 01 A CKLSB CMPB 1,X MATCH ?
0750A F4BA 26 F1 F4AD BNE NEXT NO,TRY NEXT ENTRY
0751A F4BC 6D 03 A TST 3,X BREAKPOINT ACTIVE ?
0752A F4BE 27 ED F4AD BEQ NEXT NO,TRY AGAIN
0753A F4C0 0D SEC YES,FOUND IT
0754A F4C1 FF E442 A STX BKPNTN SAVE ADDR
0755A F4C4 39 RTS

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FUNCT

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0758 *****
0759 *
0760 * FSET - SET FUNCTION FLAG & DISPLAY "FS"
0761 *
0762 *****
0763A F4C5 86 01 A FSET LDAA #$01 TO SET FUNCTION FLAG
0764A F4C7 CE 716D A LDX #$716D CODE FOR 'FS'
0765A F4CA B7 E43E A FOUT STAA FNCFL
0766A F4CD FF E421 A STX DISBUF+4 .
0767A F4D0 39 RTS RETURN TO PUT
0768 *****
0769 *
0770 * FCLR - CLEAR FUNCTION FLAG & LAST 2 DIGITS
0771 *
0772 *****
0773A F4D1 4F FCLR CLRA TO CLEAR FUNCTION FLAG
0774A F4D2 CE 0000 A LDX #$0000 TO CLEARLAST 2 DIGITS
0775A F4D5 20 F3 F4CA BRA FOUT

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TAPES

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0778 *****
0779 *
0780 * TAPES - SOFTWARE CASSETTE TAPE INTERFACE
0781 *
0782 *****
0783A F4D7 7D E43E A TAPBEG TST FNCFL SEE IF PUNCH OR LOAD
0784A F4DA 27 06 F4E2 BEQ PCH
0785A F4DC BD F69C A LDTAP JSR LOAD DO LOAD (OR VERF)
0786A F4DF 7E F024 A JMP PROMPT WHEN DONE
0787 *
0788A F4E2 CE F4EC A PCH LDX #BEGEND POINT AT BEGEND ROUTINE
0789A F4E5 FF E419 A STX MNPTR ACTIVATE
0790A F4E8 86 BB A LDAA #SBB
0791A F4EA 20 1D F509 BRA CONOUT DISPLAY BB IN LAST DISPLAYS
0792 *
0793A F4EC 7D E41C A BEGEND TST KYFLG SEE IF KEY PENDING
0794A F4EF 26 01 F4F2 BNE ADNOW
0795A F4F1 39 RTS ** RETURN ** NO KEY
0796 *
0797A F4F2 BD F1EF A ADNOW JSR RDKEY READ & ACKNOWLEDGE KEY
0798A F4F5 2B 05 F4FC BMI FUNK FUNCTION KEY
0799A F4F7 BD F1CC A JSR ROLL4 ENTER NEW NUMBER
0800A F4FA 20 16 F512 BRA DYSOUT CONVERT TO 7-SEG & LEAVE
0801 *
0802A F4FC 86 EE A FUNK LDAA #SEE
0803A F4FE B1 E42E A CMPA HEXBUF+2 END ADDR DONE ?
0804A F501 27 12 F515 BEQ DOPCH GO DO PUNCH
0805A F503 FE E42C A LDX HEXBUF SAVE ENTERED ADDR
0806A F506 FF E460 A STX BEGAD
0807A F509 B7 E42E A CONOUT STAA HEXBUF+2 'EE' OR 'BB' TO LAST DISPLAYS
0808A F50C 7F E42C A CLR HEXBUF CLEAR FIRST FOUR NIBBLES
0809A F50F 7F E42D A CLR HEXBUF+1
0810A F512 7E F120 A DYSOUT JMP DYSCOD CONV & RETURN
0811 *
0812A F515 FE E42C A DOPCH LDX HEXBUF SAVE ENTERED ADDR
0813A F518 FF E462 A STX ENDAD
0814A F51B BD F630 A JSR PUNCH PUNCH TAPE
0815A F51E 7E F024 A JMP PROMPT WHEN DONE
0816 *

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TAPES

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0818 *****
0819 * FEDGE - ROUTINE TO LOCATE AN EDGE (POS OR NEG)
0820 *          AND DETERMINE DISTANCE TO IT (TIME)
0821 *          EXECUTION TIME TUNED
0822 *****
0823 *
0824A F521 86 05 A FEDGE LDAA #5 8 FOR BSR
0825A F523 F6 E484 A LDAB PIADP 2 START COUNT=FIXED (-1)
0826A F526 01 NOP 4 CLEAR INTERRUPT
0827A F527 4C LOOPF INCA 2 DELAY
0828A F528 F6 E485 A LDAB PIACR 2 DURATION COUNT IN A-REG
0829A F52B 2A FA F527 BPL LOOPF 4 CHECK FOR EDGE FOUND
0830A F52D C8 02 A EORB #$02 4 IF NOT;KEEP LOOKING
0831A F52F F7 E485 A STAB PIACR 2 INVERT EDGE SENSE CONTROL
0832A F532 39 RTS 5 PIA LOOKS FOR OTHER EDGE
                    5 **RETURN**

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```

0834 *****
0835 * TIN - READ 1 BYTE FROM TAPE
0836 *          TIME TUNED
0837 *
0838 *****
0839 *
0840A F533 86 FF A TIN LDAA #$FF 9 FOR JSR
0841A F535 B7 E459 A STAA BYTE 2
0842A F538 7F E45A A CLR CYCNT 5 INITIALIZE BYTE
0843A F53B 7F E45B A CLR CYCNT+1 6
0844A F53E 7F E45C A CLR GOODLS 6 INIT BIT-TIME COUNT
0845A F541 8D DE F521 BSR FEDGE 6 INIT LOGIC SENSE
0846A F543 7D F543 A TST * [22/21+-5] SYNC TO AN EDGE
0847A F546 7D F546 A NOTSH TST * 6 DELAY
0848A F549 B7 E45D A STAA OLD 5 DELAY
0849A F54C 8D D3 F521 BSR FEDGE 5 "
0850A F54E 81 1B A CMPA #27 [22/21+-5] MEASURE TO NEXT EDGE
0851A F550 2C F4 F546 BGE NOTSH 2 <1.5 SHORT HALF ?
0852A F552 B7 E45D A LOOPS STAA OLD 4 MUST FIND SHORT FIRST
0853A F555 8D CA F521 BSR FEDGE 5 SAVE LAST COUNT
0854A F557 16 TAB [22/21+-5] MEASURE TO NEXT
0855A F558 FB E45D A ADDB OLD 2 MAKE EXTRA COPY
0856A F55B C1 2B A CMPB #43 4 SUM OF LAST 2
0857A F55D 2F F3 F552 BLE LOOPS 2 >2.33 NOM. SHORTS?
0858 * 4 KEEP LOOKING FOR LONG
0859 *
0860 * EDGE SENSE SET-UP TO SENSE TRAILING EDGE OF CYCLES
0861 * & YOU ARE IN THE MIDDLE OF THE FIRST LONG CYCLE
0862A F55F 7E F562 A JMP *+3 3 DELAY
0863A F562 F6 E484 A LDAB PIADP 4 CLEAR INTERRUPT FLAG
0864A F565 8B 05 A ADDA #5 2 COMPENSATE FOR PROCESSING
0865A F567 20 10 F579 BRA SYNCIN 4 BRANCH INTO COUNT LOOP
0866A F569 86 00 A LPOUT LDAA #0 2 INIT BIT-TIME COUNT
0867A F56B 20 00 F56D BRA LPMID 4 DELAY
0868A F56D 7F E45A A LPMID CLR CYCNT 6
0869A F570 B7 E45B A STAA CYCNT+1 5 ESTABLISH BIT-TIME COUNT
0870A F573 7F E45C A CLR GOODLS 6 INIT LOGIC SENSE
0871A F576 86 0A A LPIN LDAA #10 2 FIXED TIME (-1)= INIT COUNT
0872A F578 4C LOOP1 INCA 2 A-REG HOLDS DURATION COUNT
0873A F579 F6 E485 A SYNCIN LDAB PIACR 4 EDGE YET?

```

TAPES

0874A	F57C	2A	FA	F578	BPL	LOOP1	4	IF NOT;KEEP LOOKING
0875A	F57E	F6	E484	A	LDAB	PIADP	4	CLEAR INTERRUPT FLAG
0876A	F581	7D	F581	A	TST	*	6	DELAY TO MAKE PASS TIME...
0877A	F584	01			NOP		2	EVEN MULTIPLE OF LOOP TIME
0878A	F585	81	34	A	CMPA	#52	2	<1.4 SHORT ?
0879A	F587	2D	05	F58E	BLT	SHRT	4	
0880A	F589	7C	E45C	A	INC	GOOD1S	6	GOOD1S POS MEANS 0
0881A	F58C	20	05	F593	BRA	WITHIN	4	
0882A	F58E	7A	E45C	A	SHRT DEC	GOOD1S	6	GOOD1S NEG MEANS 1
0883A	F591	20	00	F593	BRA	WITHIN	4	DELAY
0884A	F593	F6	E45A	A	WITHIN LDAB	CYCNT	4	HIGH BYTE
0885A	F596	BB	E45B	A	ADDA	CYCNT+1	4	ADD CURRENT TO BIT-TIME COUNT
0886A	F599	B7	E45B	A	STAA	CYCNT+1	5	UPDATE
0887A	F59C	C9	00	A	ADCB	#0	2	ADD IN CARRY
0888A	F59E	F7	E45A	A	STAB	CYCNT	5	UPDATE HIGH BYTE
0889A	F5A1	26	03	F5A6	BNE	CHKOVR	4	IF CARRY; BIT MAY BE OVER
0890A	F5A3	01			NOP		2	DELAY
0891A	F5A4	20	04	F5AA	BRA	NOTOVR	4	BIT NOT OVER
0892A	F5A6	81	17	A	CHKOVR CMPA	#23	2	(279-256)
0893A	F5A8	2C	0A	F5B4	BGE	BITOVR	4	BIT-TIME EXPIRED
0894A	F5AA	C6	05	A	NOTOVR LDAB	#5	[38]	2
0895A	F5AC	5A			DECB		"	2
0896A	F5AD	2A	FD	F5AC	BPL	*-1	"	4
0897A	F5AF	7E	F5B2	A	JMP	*+3	3	
0898A	F5B2	20	C2	F576	BRA	LPIN	4	
0899					*			
0900					*	END OF A BIT-TIME		
0901					*			
0902A	F5B4	78	E45C	A	BITOVR ASL	GOOD1S	6	LOGIC SENSE TO CARRY
0903A	F5B7	76	E459	A	ROR	BYTE	6	SHIFT NEW BIT INTO BYTE
0904A	F5BA	24	08	F5C4	BCC	TINDUN	4	DONE WHEN START FALLS OUT
0905A	F5BC	81	5D	A	CMPA	#93	2	>2.5 NOM. SHORTS ?
0906A	F5BE	2D	A9	F569	BLT	LPOUT	4	NO; BIT-TIME STARTS AT 0
0907A	F5C0	86	24	A	LDAA	#36	2	YES; TRY MAINTAIN FRAMING
0908A	F5C2	20	A9	F56D	BRA	LPMID	4	NEXT BIT-TIME
0909					*			
0910					*	DATA BYTE READ; CLEAN-UP AND LEAVE		
0911					*			
0912A	F5C4	B6	E459	A	TINDUN LDAA	BYTE	4	GET CURRENT BYTE
0913A	F5C7	BB	E45E	A	ADDA	CHKSM	4	ADD TO CHECKSUM
0914A	F5CA	B7	E45E	A	STAA	CHKSM	5	UPDATE
0915A	F5CD	B6	E459	A	LDAA	BYTE	4	GET RECEIVED DATA IN A-REG
0916A	F5D0	39			RTS		5	** RETURN **

TAPES

```

0918 *****
0919 * BIT1 - SEND A LOGIC 1 BIT-TIME
0920 * LESS 177 CLOCK CYCLES
0921 * TIME TUNED
0922 *****
0923 *
0924A F5D1 C6 0F A BIT1 LDAB #15 8 FOR BSR
0925A F5D3 BD F5FF A LOOPB1 JSR INVRT 2 # SHORT H-CYCS (-1)
0926A F5D6 86 18 A LDAA #24 [20/5] TRANSMIT EDGE
0927A F5D8 4A DECA " 2 [152] 2 DELAY
0928A F5D9 2A FD F5D8 BPL *-1 " 4
0929A F5DB 20 00 F5DD BRA *+2 4 DELAY
0930A F5DD 5A DECB 2 1 LESS HALF CYCLE
0931A F5DE 26 F3 F5D3 BNE LOOPB1 4 TILL 2ND LAST EDGE
0932A F5E0 BD F5FF A JSR INVRT [20/5] 15TH EDGE IN BIT-TIME
0933A F5E3 39 RTS 5 **RETURN** 177 CYC TO NXT

```

```

0935 *****
0936 * BIT0 - SEND A LOGIC 0 BIT-TIME
0937 * LESS 177 CLOCK CYCLES
0938 * TIME TUNED
0939 *****
0940 *
0941A F5E4 C6 07 A BIT0 LDAB #7 8 FOR BSR
0942A F5E6 BD F5FF A LOOPB0 JSR INVRT 2 # LONG H-CYCS (-1)
0943A F5E9 86 38 A LDAA #56 [20/5] TRANSMIT EDGE
0944A F5EB 4A DECA " 2 [344] 2 DELAY
0945A F5EC 2A FD F5EB BPL *-1 " 4
0946A F5EE 01 NOP 2 DELAY
0947A F5EF 5A DECB 2 1 LESS TO GO
0948A F5F0 26 F4 F5E6 BNE LOOPB0 4 TILL 2ND LAST EDGE
0949A F5F2 BD F5FF A JSR INVRT [20/5] 7TH EDGE IN BIT-TIME
0950A F5F5 86 1D A LDAA #29 [182] 2 DELAY
0951A F5F7 4A DECA " 2
0952A F5F8 2A FD F5F7 BPL *-1 " 4
0953A F5FA 7E F5FD A JMP *+3 3 DELAY
0954A F5FD 01 NOP 2 "
0955A F5FE 39 RTS 5 **RETURN** 177 CYC TO NXT

```

```

0957 *****
0958 * INVRT - ROUTINE TO TRANSMIT A RISING
0959 * OR FALLING EDGE TO THE CASSETTE
0960 * TIME TUNED
0961 *****
0962 *
0963A F5FF 86 80 A INVRT LDAA #$80 9 FOR JSR
0964A F601 B8 E486 A EORA PIADPB 2
0965A F604 B7 E486 A STAA PIADPB 4
0966A F607 39 RTS 5 INVERT OUTPUT
5 ** RETURN **

```

TAPES

```

0968 *****
0969 * PNCHB - PUNCH 1 BYTE TO TAPE. INCLUDES
0970 * START BIT, DATA, AND ALL BUT LAST HALF-CYCLE
0971 * OF STOP BITS
0972 * TIME TUNED
0973 *****
0974 *
0975A F608 B7 E459 A PNCHB STAA BYTE 9 FOR JSR
0976A F60B 8D D7 F5E4 BSR BIT0 5 SAVE BYTE TO PUNCH
0977A F60D 86 09 A LDAA #9 [30/<177>] SEND START BIT
0978A F60F B7 E45F A STAA NBITS 2 # BITS IN BYTE (+2 STOP) (-1)
0979A F612 7D F612 A TST * 5 ESTABLISH BIT COUNT
0980A F615 86 13 A LPPOUT LDAA #19 6 DELAY
0981A F617 4A DECA [122] 2 DELAY
0982A F618 2A FD F617 BPL *-1 " 2
0983A F61A 0D SEC " 4
0984A F61B 76 E459 A ROR BYTE 2 SO LAST 2 BIT TIMES = 1'S
0985A F61E 25 05 F625 BCS D01 6 LOGIC SENSE TO CARRY
0986A F620 8D C2 F5E4 BSR BIT0 4 IF LOGIC 1
0987A F622 7E F62A A JMP ENDBIT [30/<177>] XMIT A 0 BIT-TIME
0988A F625 8D AA F5D1 D01 BSR BIT1 3
0989A F627 7E F62A A JMP ENDBIT [30/<177>] XMIT A 1 BIT-TIME
0990A F62A 7A E45F A ENDBIT DEC 3 MATCHING DELAY
0991A F62D 2A E6 F615 BPL LPPOUT 6 1 LESS BIT-TIME TO GO
0992A F62F 39 RTS 4 CONTINUE FOR BYTE+STOP BITS
5 ** RETURN ** 159 CYC TO NXT

```

TAPES

```

0994 *****
0995 * PUNCH - FORMAT AND PUNCH A CASSETTE DATA FILE
0996 * INCLUDING LEADER AND CHECKSUM
0997 * EXECUTION TIME TUNED
0998 *****
0999 *
1000A F630 CE 0348 A PUNCH LDX #840 9 FOR JSR
1001A F633 86 FF A LLOOP LDAA #$FF 3 COUNT FOR 30-SEC LEADER
1002A F635 C6 10 A LDAB #16 2 LEADER CHARACTER
1003A F637 5A DECB " 2 [104] 2 DELAY
1004A F638 2A FD F637 BPL *-1 " 4
1005A F63A BD F608 A JSR PNCHB [44/<159>] PUNCH A LEADER CHAR
1006A F63D 09 DEX 4
1007A F63E 26 F3 F633 BNE LLOOP 4 CONTINUE FOR 30-SEC
1008 *
1009 * LEADER FINISHED
1010 *
1011A F640 86 53 A LDAA #'S 2 BLOCH START CHAR
1012A F642 C6 10 A LDAB #16 [104] 2 DELAY
1013A F644 5A DECB " 2
1014A F645 2A FD F644 BPL *-1 " 4
1015A F647 BD F608 A JSR PNCHB [44/<159>] PUNCH START CHAR
1016A F64A 01 NOP 2 DELAY
1017A F64B 7F E45E A CLR CHKSM 6 INITIALIZE CHECKSUM
1018A F64E CE E460 A LDX #BEGAD 3 POINT AT FIRST ADDR BYTEOLT
1019A F651 A6 00 A ADLOOP LDAA 0,X
1020A F653 16 TAB 2 EXTRA COPY
1021A F654 FB E45E A ADDDB CHKSM 4 ADDR IS PART OF CHECKSUM
1022A F657 F7 E45E A STAB CHKSM 5 UPDATE
1023A F65A 01 NOP 2 DELAY
1024A F65B C6 0D A LDAB #13 [86] 2
1025A F65D 5A DECB " 2
1026A F65E 2A FD F65D BPL *-1 " 4
1027A F660 BD F608 A JSR PNCHB [44/<159>] PUNCH ADDR BYTE
1028A F663 08 INX 4 ADV TO NXT ADDR BYTE
1029A F664 8C E464 A CPX #BEGAD+4 3 DONE YET ?
1030A F667 26 E8 F651 BNE ADLOOP 4 CONTINUE FOR 4 ADDR CHARS
1031 *
1032 * READY TO PUNCH DATA
1033 *
1034A F669 01 NOP 2 DELAY
1035A F66A 01 NOP 2 DELAY
1036A F66B FE E460 A LDX BEGAD 5 GET BEG ADDR OF DATA
1037A F66E A6 00 A DLOOP LDAA 0,X 5 GET A DATA BYTE
1038A F670 16 TAB 2 EXTRA COPY
1039A F671 FB E45E A ADDDB CHKSM 4 ADD TO CHECKSUM
1040A F674 F7 E45E A STAB CHKSM 5 UPDATE
1041A F677 F7 E45E A STAB CHKSM 5 DELAY
1042A F67A C6 0B A LDAB #11 [74] 2
1043A F67C 5A DECB " 2
1044A F67D 2A FD F67C BPL *-1 " 4
1045A F67F BD F608 A JSR PNCHB [44/<159>] PUNCH DATA BYTE
1046A F682 7E F685 A JMP *+3 3 DELAY
1047A F685 BC E462 A CPX ENDA 5 SEE IF DONE
1048A F688 27 03 F68D BEQ DUNDAT 4 IF FINISHED
1049A F68A 08 INX 4 ELSE ADV TO NXT
1050A F68B 20 E1 F66E BRA DLOOP 4 AND CONTINUE LOOP

```

TAPES

1052				*				
1053				*	READY TO PUNCH CHECKSUM			
1054				*				
1055A	F68D	70	E45E	A	DUNDAT	NEG	CHKSM	6 SUM INCL, CHECK WILL BE 0
1056A	F690	B6	E45E	A	LDAA	CHKSM		4 PREPARE TO SEND
1057A	F693	C6	14	A	LDAB	#20		[128] 2
1058A	F695	5A			DECB			" 2
1059A	F696	2A	FD F695		BPL	*-1		" 4
1060A	F698	BD	F608	A	JSR	PNCHB		[44/<159>] PUNCH CHECKSUM
1061A	F69B	39			RTS			5 ** RETURN **

TAPES

```

1063 *****
1064 *
1065 * LOAD - LOAD OR VERIFY A DATA FILE FROM
1066 * CASSETTE TAPE
1067 *
1068 *****
1069 *
1070A F69C BD F533 A LOAD JSR TIN 9 FOR A JSR
1071A F69F 81 53 A CMPA #'S [56/101+-5] READ A BYTE FROM TAPE
1072A F6A1 26 F9 F69C BNE LOAD 2 BLOCK START ?
1073 * 4 NO; TRY AGAIN
1074 * BLOCK START FOUND; NOW READ BEG & END ADDR'S
1075 *
1076A F6A3 CE E460 A LDX #BEGAD 3 POINT AT ADDR AREA
1077A F6A6 7F E45E A CLR CHKSM 6 INITIALIZE CHECKSUM
1078A F6A9 BD F533 A LOPAD JSR TIN [56/101+-5] GET ADDR CHAR
1079A F6AC A7 00 A STAA 0,X 6 STORE RECIEVED ADDR CHAR
1080A F6AE 08 INX 4 POINT AT NEXT ADDR LOC
1081A F6AF 8C E464 A CPX #BEGAD+4 3 DONE GETTING ADDR'S ?
1082A F6B2 26 F5 F6A9 BNE LOPAD 4 NO; CONTINUE
1083 *
1084 * READY TO READ DATA
1085 *
1086A F6B4 FE E460 A LDX BEGAD 5 POINT TO WHERE DATA GOES
1087A F6B7 BD F533 A LOPDAT JSR TIN [56/101+-5] GET DATA FROM TAPE
1088A F6BA 7D E43E A TST FNCFL 6 SEE IF LOAD OR VERF ?
1089A F6BD 27 04 F6C3 BEQ VERF 4 IF NOT SET; IT'S VERF
1090A F6BF A7 00 A STAA 0,X 6 IT'S LOAD SO STORE DATA
1091A F6C1 20 04 F6C7 BRA LOPBOT 4 GO TO BOTTOM OF LOOP
1092A F6C3 A1 00 A VERF CMPA 0,X 5 JUST COMPARE TO MEM
1093A F6C5 26 11 F6D8 BNE BAD 4 IF NON-COMPARE; SIGNAL ERROR
1094A F6C7 BC E462 A LOPBOT CPX ENDAD 5 DONE ?
1095A F6CA 27 03 F6CF BEQ CHKCHK 4 IF SO; CHECK CHECKSUM
1096A F6CC 08 INX 4 POINT AT NEXT DATA LOC
1097A F6CD 20 E8 F6B7 BRA LOPDAT 4 AND CONTINUE LOAD/VERF
1098 *
1099 * DATA FINISHED... NOW CHECK CHECKSUM
1100 *
1101A F6CF BD F533 A CHKCHK JSR TIN [56/105+-5] GET CHECKSUM
1102A F6D2 7D E45E A TST CHKSM
1103A F6D5 26 01 F6D8 BNE BAD 4 IF NOT ZERO; BAD CHECKSUM
1104A F6D7 39 RTS 5 ** RETURN **
1105 *
1106A F6D8 FF E434 A BAD STX UX 6 SO USER CAN SEE END ADDR
1107A F6DB B7 E433 A STAA UA 5 SO USER CAN CHECK IT
1108A F6DE 7D E43E A TST FNCFL CHECK FOR ERROR OVERRIDE
1109A F6E1 2A 01 F6E4 BPL STOP
1110A F6E3 39 RTS ** RETURN ** NO MESSAGE
1111 *
1112A F6E4 CE 7177 A STOP LDX #$7177 "FA"
1113A F6E7 FF E41D A STX DISBUF
1114A F6EA CE 0638 A LDX #$0638 "IL"
1115A F6ED FF E41F A STX DISBUF+2
1116A F6F0 7E F735 A JMP ALTBAD PRINT "FAIL ??"

```

GO

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1119 *****
1120 *
1121 * GO - GO TO USER PROGRAM
1122 *
1123 *****
1124A F6F3 7D E423 A GO TST ROLPAS HEX DATA PRIOR TO 'GO' ?
1125A F6F6 26 06 F6FE BNE CONTIN IF NOT; ASSUME UPC
1126A F6F8 FE E42C A LDX HEXBUF GET ENTERED VALUE
1127A F6FB FF E436 A STX UPC STORE AS GO ADDR
1128A F6FE CE F70B A CONTIN LDX #G01 RETURN ADDR AFTER ROI
1129A F701 FF E439 A ROI STX ROIBAK SAVE IN RAM
1130A F704 86 01 A LDAA #1
1131A F706 B7 E438 A STAA ROIFLG SIGNAL SINGLE TRACE
1132A F709 20 03 F70E BRA GOTO EXIT (NO BREAKS)
1133 * COME HERE AFTER RUNNING ONE INSTRUCTION
1134A F70B BD F45F A G01 JSR INBKS INSTALL BREAKPOINTS
1135A F70E BE E42F A GOTO LDS USP GET USER'S STACK POINTER
1136A F711 86 55 A LDAA #$55 START TEST FOR EXISTANCE OF STK
1137A F713 36 PSHA
1138A F714 32 PULA
1139A F715 81 55 A CMPA #$55 DID IT GO ?
1140A F717 26 10 F729 BNE BADSTK NO; STACK IS BAD
1141A F719 B6 E437 A LDAA UPC+1 LOW BYTE
1142A F71C 36 PSHA STACK FOR RTS
1143A F71D B6 E436 A LDAA UPC HIGH BYTE
1144A F720 36 PSHA
1145A F721 86 AA A LDAA #$AA SEE IF STACK STILL OK
1146A F723 36 PSHA
1147A F724 32 PULA
1148A F725 81 AA A CMPA #$AA
1149A F727 27 1E F747 BEQ GOEXIT OK; FINAL EXIT SEQ
1150A F729 CE 406D A BADSTK LDX #$406D MESSAGE "-SP- ?? " TO 7-SEGS
1151A F72C FF E41D A STX DISBUF
1152A F72F CE 7340 A LDX #$7340
1153A F732 FF E41F A STX DISBUF+2
1154A F735 CE 5353 A ALTBAD LDX #$5353
1155A F738 FF E421 A STX DISBUF+4
1156A F73B 8E E47E A LDS #STKTOP INIT TO GOOD AREA
1157A F73E CE F0A2 A LDX #DIDDLE DO-NNOTHING SUB
1158A F741 FF E419 A STX MNPTR STORE AS MAIN PROG
1159A F744 7E F0BB A JMP PUT ONLY ESCAPE IS RESET OR 'EX'
1160 *
1161A F747 FE E434 A GOEXIT LDX UX RECOVER USER STATUS
1162A F74A F6 E432 A LDAB UB
1163A F74D B6 E433 A LDAA UA
1164A F750 36 PSHA TEMP SAVE ON USER'S STACK
1165A F751 86 01 A LDAA #1
1166A F753 B7 E43B A STAA UPROG FLAG SIGNALS IN USER PROG
1167A F756 7D E438 A TST ROIFLG TRACE EXIT ?
1168A F759 27 12 F76D BEQ ABSOUT IF NOT;; JUST GET GOING
1169A F75B 86 3C A LDAA #$3C
1170A F75D B7 E485 A STAA PIACRA HOLDS TRACE COUNTER RESET
1171A F760 B6 E486 A LDAA PIAPB READ TO CLEAR ANY INT FLAG
1172A F763 86 0E A LDAA #$0E
1173A F765 B7 E487 A STAA PIACRB ENABLE TRACE NMI
1174A F768 86 34 A LDAA #$34
1175A F76A B7 E485 A STAA PIACRA RELEASE TIMER
1176A F76D B6 E431 A ABSOUT LDAA UCC TIMED EXIT TO USER PROG

```

GO

1177A F770 06
1178A F771 32
1179A F772 39
1180

*

TAP
PULA
RTS

SET USER COND CODES
GET USER A-REG; DON'T MESS 'CC'
*** EXIT TO USER PROG ***

INTS

```

1184 *****
1185 *
1186 * INTERRUPTS - INTERRUPT HANDLING ROUTINES
1187 *
1188 *****
1189A F773 01 NMINT NOP SET IRQ FLAG
1190A F774 0F SEI .
1191A F775 86 04 A LDAA #$04 PIA DISABLE CODE
1192A F777 B7 E487 A STAA PIACRB DISABLE NMI'S DURING SERVICE
1193A F77A B6 E487 A LDAA PIACRB READ INT STATUS
1194A F77D 2A 12 F791 BPL SAVE IF RETURN FROM TRACE
1195 * KEY CLOSURE CAUSED NMI
1196A F77F BD F04E A JSR GET FIND AND DEBOUNCE KEY
1197A F782 81 81 A CMPA #$81 'EX' ?
1198A F784 27 03 F789 BEQ ABORT
1199A F786 8D 26 F7AE BSR ENNMI RE-ENABLE INTERRUPT
1200A F788 3B RTI *** DONE: RETURN ***
1201 * 'EX' KEY; PROMPT OR ABORT
1202A F789 7D E43B A ABORT TST UPROG ESCAPE FROM USER PROG ?
1203A F78C 26 03 F791 BNE SAVE IF ESCAPE FROM USER PROG
1204A F78E 7E F024 A JMP PROMPT *** ALREADY IN OP-SYST ***
1205A F791 BF E42F A SAVE STS USP SAVE POINTER TO USER REGS
1206A F794 8E E47E A LDS #STKTOP INIT TO SYST AREA
1207A F797 8D 23 F7BC BSR SVSTAT RECOVER STATUS AT 'EX' TIME
1208A F799 8D 13 F7AE BSR ENNMI RE-ENABLE KEY NMI
1209A F79B 7F E43B A CLR UPROG SIGNAL NOT IN USER PROGRAM
1210A F79E 7D E438 A TST ROIFLG IS THIS RETURN FROM TRACE ?
1211A F7A1 27 08 F7AB BEQ NOTROI IF NOT
1212A F7A3 7F E438 A CLR ROIFLG SIGNAL NOT ROI NOW
1213A F7A6 FE E439 A LDX ROIBAK GET RETURN ADDR
1214A F7A9 6E 00 A JMP 0,X AND RETURN FROM ROI
1215A F7AB 7E F2CA A NOTROI JMP REGBEQ *** TO REG DISPLAY ***
1216 *
1217 *
1218A F7AE B6 E486 A ENNMI LDAA PIAPB TO CLEAR FLAGS
1219A F7B1 86 07 A LDAA #$07 ENABLE KEY INTERRUPT CODE
1220A F7B3 B7 E487 A STAA PIACRB TO PIA CONTROL REG
1221A F7B6 86 FF A LDAA #$FF
1222A F7B8 B7 E486 A STAA PIAPB ENABLE ALL KEY ROWS
1223A F7BB 39 RTS ** RETURN **
1224 *
1225 *
1226A F7BC BE E42F A SVSTAT LDS USP POINT AT STACKED STATUS
1227A F7BF CE E431 A LDX #UCC POINT AT PSEUDO REG AREA
1228A F7C2 32 SVLOOP PULA GET STACKED BYTE
1229A F7C3 A7 00 A STAA ,X STORE AT PSEUDO REG RAM LOC
1230A F7C5 08 INX POINT AT NEXT REG LOC
1231A F7C6 8C E438 A CPX #UPC+2 PAST END ?
1232A F7C9 26 F7 F7C2 BNE SVLOOP IF NOT CONTINUE LOOP
1233A F7CB BF E42F A STS USP SAVE USER SP AT INTERRUPT TIME
1234A F7CE 8E E47C A LDS #STKTOP-2 SET FOR RETURN
1235A F7D1 39 RTS ** RETURN **
1236 *
1237 *
1238A F7D2 01 SWINT NOP SET IRQ FLAG
1239A F7D3 0F SEI .
1240A F7D4 BF E42F A STS USP POINTER TO USER'S REGS
1241A F7D7 8E E47E A LDS #STKTOP INIT TO SYST AREA

```

DUMY READ DROPS THE FLAG

INTS

1242A	F7DA	8D	E0	F7BC		BSR	SVSTAT	RECOVER BREAK STATUS
1243A	F7DC	FE	E436	A		LDX	UPC	BACK UP PROG CNTR
1244A	F7DF	09				DEX		.
1245A	F7E0	FF	E436	A		STX	UPC	.
1246A	F7E3	BD	F485	A		JSR	OUTBKS	TAKE OUT BREAKPOINTS
1247A	F7E6	7F	E43B	A		CLR	UPROG	SIGNAL NOT IN USER PROG
1248A	F7E9	7E	F2CA	A		JMP	REGBEG	*** TO REG DISPLAY ***
1249					*			
1250					*			
1251A	F7EC	FE	E43C	A	UIRQ	LDX	UIRQV	GET USER IRQ VECTOR
1252A	F7EF	6E	00	A		JMP	0,X	*** GO TO USER SERVICE ROUTINE ***
1253					*			

DEFS

```

1256 *****
1257 *
1258A E419          ORG      $E419
1259 *
1260 * DEFS - DEFINITIONS & SCRATCH LOCATIONS
1261 *
1262 *****
1263A E419      0002  A MNPTR  RMB      2      POINTER TO ACTIVE SUBROUTINE
1264A E41B      0001  A KEY    RMB      1      KEY DATA
1265A E41C      0001  A KYFLG  RMB      1      KEY PENDING FLAG
1266A E41D      0006  A DISBUF RMB      6      DISPLAY BUFFER
1267A E423      0001  A ROLPAS RMB      1      FIRST PASS OF DATA ROL-ENT
1268A E424      0002  A XSAVD  RMB      2      X SCRATCH
1269A E426      0002  A XSAVL  RMB      2      .
1270A E428      0002  A XTMP1  RMB      2      .
1271A E42A      0002  A MEMSAV RMB      2      SAVE MEM POINTER DURING OFFSET CAL
1272A E42C      0003  A HEXBUF RMB      3      HEX INPUT BUFFER
1273A E42F      0002  A USP    RMB      2      USER STACK POINTER
1274A E431      0001  A UCC    RMB      1      USER CONDITION CODE
1275A E432      0001  A UB     RMB      1      USER B REGISTER
1276A E433      0001  A UA     RMB      1      USER A REGISTER
1277A E434      0002  A UX     RMB      2      USER X REGISTER
1278A E436      0002  A UPC    RMB      2      USER PROGRAM COUNTER
1279A E438      0001  A ROIFLG RMB      1      RUN-ONE-INSTRUCTION FLAG
1280A E439      0002  A ROIBAK RMB      2      ADDR TO RETURN TO AFTER ROI
1281A E43B      0001  A UPROG  RMB      1      FLAG INDICATES IN-USER-PROG
1282A E43C      0002  A UIRQV  RMB      2      ADDR OF USER'S IRQ SERVICE ROUTINE
1283A E43E      0001  A FNCFL  RMB      1      SPECIAL FUNCTION FLAG
1284A E43F      0002  A FNCPNT RMB      2      POINT TO USER'S SPECIAL FUNCTION
1285A E441      0001  A REGNO  RMB      1      REGISTER NUMBER (USED IN REGDIS)
1286A E442      0002  A BKPNT  RMB      2      POINTS INTO BREAKPOINT TABLE
1287A E444      0001  A BRKNO  RMB      1      # OF BREAKPOINTS IN TABLE
1288A E445      0014  A BRKTAB RMB     20      BREAKPOINT TABLE
1289      E459  A BRKEND  EQU      *      END OF TABLE
1290 *
1291 * CASSETTE INTERFACE SCRATCH LOCATIONS
1292 *
1293A E459      0001  A BYTE    RMB      1      DATA BUFFER
1294A E45A      0002  A CYCNT  RMB      2      CYCLE COUNT REG
1295A E45C      0001  A GOOD1S RMB      1      # OF GOOD 1'S
1296A E45D      0001  A OLD    RMB      1
1297A E45E      0001  A CHKSM  RMB      1      CHECKSUM REG
1298A E45F      0001  A NBITS  RMB      1
1299A E460      0002  A BEGAD  RMB      2      BEGINNING ADDRESS
1300A E462      0002  A ENDAD  RMB      2      END ADDRESS
1301 *
1302      E484  A PIA      EQU      $E484      SYSTEM PIA BASE ADDR
1303      0000  A KPCOL   EQU      $0         KEYPAD COL PORT OFFSET
1304      0002  A KPROW   EQU      $2         KEYPAD ROW PORT OFFSET
1305      E484  A ANOD     EQU      $E484      DISPLAY SEG ANODES
1306      E486  A CATH     EQU      $E486      DISPAY CATHODES
1307      E486  A PIAROW  EQU      $E486      EXTENDED MODE ROW PORT ADDR
1308      E486  A PIADPB  EQU      $E486      PIA DATA PORT B
1309      E485  A PIACR   EQU      $E485      PIA CONTROL REG A
1310      E484  A PIADP   EQU      $E484      PIA DATA PORT A
1311      E485  A PIACRA  EQU      $E485      PIA CONTROL REG A
1312      E487  A PIACRB  EQU      $E487      PIA CONTROL REG B
1313      E486  A PIAPB   EQU      $E486      PIA DATA PORT B

```

DEFS

```

1314      E47E  A STKTOP EQU      $E47E      TOP OF SYSTEM STACK
1315      *
1316      * SYSTEM VECTORS
1317      *
1318      * ON MEK6802D5 EITHER UPPER HALF
1319      * OF D5BUG ($F400-F7FF) MUST "MIRROR"
1320      * INTO ADDRESSES ($FC00-FFFF) OR
1321      * ELSE USER MUST SUPPLY PROM
1322      * MAPPED IN ($FC00-FFFF) AREA WHICH
1323      * CONTAINS ALTERNATE VECTORS.
1324      * IN THE CASE OF "MIRRORING" THE
1325      * FOLLOWING VECTORS WOULD ALSO
1326      * APPEAR AT THE NORMAL 6802
1327      * VECTOR LOCATIONS ($FFF8-FFFF)
1328A F7F8      ORG      $F7F8
1329A F7F8      F7EC  A      FDB      UIRQ      USER IRQ VECTOR
1330A F7FA      F7D2  A      FDB      SWINT     SOFTWARE INTERRUPT VECTOR
1331A F7FC      F773  A      FDB      NMINT     NON MASKABLE INTERRUPT VECTOR
1332A F7FE      F000  A      FDB      RESET     RESTART VECTOR
1333      END

```

ERRORS 00000--00000

```

F789 ABORT      1198  1202*
F76D ABSOUT     1168  1176*
F183 ADDAX      0089  0187  0232  0279*  0514
F651 ADLOOP     1019*  1030
F4F2 ADNOW      0794  0797*
F735 ALTBAD     1116  1154*
E484 ANOD       0145  0149  1305*
F1BC ARNCL2     0303  0307*
F1DD ARNCL4     0321  0326*
F1A0 ARNCLR     0292  0294*
F191 ARND       0282  0284*
F243 ARNINC     0382  0384*
F30A ARNR1      0489  0491*
F31C ARNR2      0499  0501*
F365 ARNR3      0532  0536*
F3E3 BACK       0598  0612*
F6D8 BAD        1093  1103  1106*
F281 BADCAL     0404  0415*
F257 BADOFF     0385  0394*
F729 BADSTK     1140  1150*
E460 BEGAD      0806  1018  1029  1036  1076  1081  1086  1299*
F4EC BEGEND     0788  0793*
F5E4 BIT0       0941*  0976  0986
F5D1 BIT1       0924*  0988
F5B4 BITOVR     0893  0902*
F42E BKFM TB    0590  0656*
F3CB BKLOOP     0600*  0608
F444 BKLOP      0669*  0679
F43E BKNO       0625  0667*
E442 BKPNTN     0599  0609  0639  0658  0673  0694  0699  0718  0721  0754
      1286*
F3F1 BKTOTB     0587  0623*
F388 BRKBEG     0199  0569*
F38E BRKEDT     0570  0572*

```

E459	BRKEND	0604	0678	0706	0727	0745	1289*						
F4A9	BRKLOP	0739*	0746										
E444	BRKNO	0596	0613	0626	0645	0661	0667	0671	0688	1287*			
F39C	BRKPNT	0572	0577*										
E445	BRKTAB	0606	0668	0690	0714	0738	1288*						
F3A2	BRKTST	0578	0580*										
E459	BYTE	0841	0903	0912	0915	0975	0984	1293*					
F26B	CALDUN	0363	0403*										
E486	CATH	0146	0150	1306*									
F6CF	CHKCHK	1095	1101*										
F5A6	CHKOVR	0889	0892*										
E45E	CHKSM	0913	0914	1017	1021	1022	1039	1040	1041	1055	1056		
		1077	1102	1297*									
F467	CKBKPT	0691*	0707										
F3B5	CKFC	0586	0588*										
F3BC	CKGO	0589	0591*										
F4B8	CKLSB	0740	0749*										
F088	CLOP	0085*	0086										
F195	CLRDS	0041	0180	0289*	0389	0398	0435	0616					
F005	CLRLOP	0012*	0015										
F19B	CLRLP	0291*	0296										
F063	COLFND	0060	0064*										
F509	CONOUT	0791	0807*										
F6FE	CONTIN	1125	1128*										
E45A	CYCNT	0842	0843	0868	0869	0884	0885	0886	0888	1294*			
F0A2	DIDDLE	0095*	1157										
F3C0	DISBRK	0576	0596*	0657	0662								
E41D	DISBUF	0039	0138	0227	0290	0295	0369	0529	0531	0533	0534		
		0766	1113	1115	1151	1153	1155	1266*					
F3F0	DISDUN	0592	0614	0617*									
F66E	DLOOP	1037*	1050										
F171	DLY1	0147	0268*										
F169	DLY25	0087	0265*										
F17C	DLYLP	0267	0270	0272*	0273								
F179	DLYX	0271*											
F625	DOI	0985	0988*										
F515	DOPCH	0804	0812*										
F68D	DUNDAT	1048	1055*										
F080	DUNROW	0077	0080*										
F120	DYSCOD	0178	0211*	0367	0387	0396	0451	0527	0584	0612	0648		
		0810											
F512	DYSOUT	0800	0810*										
F159	DYSTBL	0230	0245*										
E462	ENDAD	0813	1047	1094	1300*								
F62A	ENDBIT	0987	0989	0990*									
F7AE	ENNMI	0044	1199	1208	1218*								
F4D1	FCLR	0197	0773*										
F521	FEDGE	0824*	0845	0849	0853								
E43E	FNCFL	0037	0175	0351	0361	0391	0400	0418	0437	0462	0464		
		0569	0765	0783	1088	1108	1283*						
E43F	FNCPNT	0182	1284*										
F4A0	FNDBRK	0623	0656	0736*									
F4CA	FOUT	0765*	0775										
F4C5	FSET	0196	0763*										
F428	FULL	0624	0628	0635	0649*								
F4FC	FUNK	0798	0802*										
F105	FUNKY	0174	0185*										
F0E5	FUNSEL	0042	0169*										

F04E GET	0054*	0063	0074	1196							
F6F3 GO	0195	1124*									
F70B GO1	1128	1134*									
F747 GOEXIT	1149	1161*									
E45C GOOD1S	0844	0870	0880	0882	0902	1295*					
F70E GOTO	1132	1135*									
F108 HASH	0183	0186*									
E42C HEXBUF	0214	0225	0301	0323	0324	0332	0333	0352	0360	0374	
	0376	0377	0378	0386	0395	0410	0449	0450	0523	0525	
	0536	0538	0597	0611	0630	0641	0642	0647	0736	0737	
	0803	0805	0807	0808	0809	0812	1126	1272*			
F45F INBKS	0688*	1134									
F5FF INVRT	0925	0932	0942	0949	0963*						
F450 ISBKPT	0672	0674*									
E41B KEY	0065	0068	0080	0082	0091	0340	1264*				
F0EB KEYNOW	0170	0173*									
0000 KPCOL	0056	0059	0070	0085	1303*						
0002 KPROW	0058	0069	1304*								
E41C KYFLG	0036	0093	0169	0339	0355	0476	0577	0793	1265*		
F0A3 KYTBL	0088	0106*									
F4DC LDTAP	0465	0785*									
F633 LLOOP	1001*	1007									
F69C LOAD	0785	1070*	1072								
F578 LOOP1	0872*	0874									
F5E6 LOOPB0	0942*	0948									
F5D3 LOOPB1	0925*	0931									
F527 LOOPF	0827*	0829									
F552 LOOPS	0852*	0857									
F6A9 LOPAD	1078*	1082									
F6C7 LOPBOT	1091	1094*									
F6B7 LOPDAT	1087*	1097									
F128 LP01	0215*	0226									
F13E LP02	0229*	0238									
F0BD LP1P	0138*	0159									
F0C1 LP2P	0140*	0142									
F057 LPCOL	0058*	0062									
F07A LPFND	0076*	0079									
F576 LPIN	0871*	0898									
F56D LPMID	0867	0868*	0908								
F569 LPOUT	0866*	0906									
F615 LPPOUT	0980*	0991									
F06A LPROW	0067*	0073									
F288 MEMBAK	0407	0413	0418*								
F1F6 MEMBEG	0192	0349*									
F205 MEMCH	0349	0355*									
F20B MEMNOW	0356	0359*									
F2BF MEMOUT	0433	0443	0448*								
E42A MEMSAV	0379	0380	0405	0417	0439	1271*					
E419 MNPTR	0043	0152	0350	0467	0573	0789	1158	1263*			
E45F NBITS	0978	0990	1298*								
F2BA NEWMEM	0353	0419	0426	0431	0445*						
F31F NEWREG	0492	0502*									
F4AD NEXT	0741*	0750	0752								
F44D NEXT1	0670	0673*									
F47B NEXT2	0692	0702*									
F496 NEXT3	0716	0723*									
F773 NMINT	1189*	1331									
F484 NOBPT	0689	0708*									

F28D	NORMAL	0362	0421*																	
F3D7	NOTEND	0605	0607*																	
F3AF	NOTHEX	0582	0585*																	
F350	NOTNEW	0521	0527*																	
F5AA	NOTOVR	0891	0894*																	
F7AB	NOTROI	1211	1215*																	
F546	NOTSH	0847*	0851																	
F2D5	NOTVRF	0463	0466*																	
F2B5	NUM	0422	0442*																	
F297	NXM1	0424	0428*																	
F29E	NXM2	0429	0432*																	
F30F	NXR1	0486	0494*																	
F221	OFFEND	0368*	0440																	
F21E	OFFOUT	0367*																		
F227	OFFRET	0370*	0373	0409	0416															
F228	OFFUN	0365	0372*																	
E45D	OLD	0848	0852	0855	1296*															
F36A	ONLY1	0535	0538*																	
F485	OUTBKS	0714*	1246																	
F4E2	PCH	0784	0788*																	
E484	PIA	0054	1302*																	
E485	PIACR	0828	0831	0873	1309*															
E485	PIACRA	1170	1175	1311*																
E487	PIACRB	1173	1192	1193	1220	1312*														
E484	PIADP	0825	0863	0875	1310*															
E486	PIADPB	0964	0965	1308*																
E486	PIAPB	1171	1218	1222	1313*															
E486	PIAROW	0094	1307*																	
F608	PNCHB	0975*	1005	1015	1027	1045	1060													
F024	PROMPT	0031*	0193	0786	0815	1204														
F630	PUNCH	0814	1000*																	
F0BB	PUT	0045	0137*	0160	0468	1159														
F1C4	R2OUT	0306	0311*																	
F1ED	R4OUT	0325	0336*																	
F1EF	RDKEY	0173	0339*	0359	0480	0580	0797													
F2CA	REGBEG	0194	0462*	0507	1215	1248														
F2EE	REGDIS	0466	0476*																	
F2FE	REGFNC	0481	0485*																	
E441	REGNO	0471	0487	0491	0496	0501	0510	1285*												
F2F4	REGNOW	0477	0480*																	
F32E	REGOUT	0474	0483	0506	0510*															
F370	REGTBL	0513	0543*																	
F488	REMOVL	0715*	0728																	
F000	RESET	0009*	1332																	
F1E3	RO4LP	0331*	0335																	
F701	ROI	0508	1129*																	
E439	ROIBAK	1129	1213	1280*																
E438	ROIFLG	0035	1131	1167	1210	1212	1279*													
F1AA	ROLL2	0300*	0442																	
F1CC	ROLL4	0177	0319*	0366	0482	0583	0799													
E423	ROLPAS	0033	0302	0304	0320	0322	0438	0446	0473	0503	0520									
		0575	0650	0681	1124	1267*														
F079	ROWFND	0071	0075*																	
F324	RUNONE	0495	0505*																	
F791	SAVE	1194	1203	1205*																
F58E	SHRT	0879	0882*																	
E47E	STKTOP	0031	0469	0470	1156	1206	1234	1241	1314*											
F6E4	STOP	1109	1112*																	

F7C2	SVLOOP	1228*	1232						
F7BC	SVSTAT	1207	1226*	1242					
F7D2	SWINT	1238*	1330						
F579	SYNCIN	0865	0873*						
F110	SYSFNC	0185	0192*						
F4D7	TAPBEG	0198	0783*						
F533	TIN	0840*	1070	1078	1087	1101			
F5C4	TINDUN	0904	0912*						
E433	UA	0546	1107	1163	1276*				
E432	UB	0549	1162	1275*					
E431	UCC	0558	1176	1227	1274*				
F100	UFNK	0176	0182*						
F7EC	UIRQ	1251*	1329						
E43C	UIRQV	1251	1282*						
E436	UPC	0543	1127	1141	1143	1231	1243	1245	1278*
E43B	UPROG	0034	1166	1202	1209	1247	1281*		
E42F	USP	0025	0555	1135	1205	1226	1233	1240	1273*
E434	UX	0552	1106	1161	1277*				
F6C3	VERF	1089	1092*						
F593	WITHIN	0881	0883	0884*					
E426	XSAV1	0213	0239	0289	0297	0300	0313	1269*	
E424	XSAVD	0265	0268	0271	0274	0279	0280	0281	0283
E428	XTMP1	0229	0234	1270*					0284
									1268*

7.7 D5BUG Listing Description

This description will be useful also for understanding other program listings in software.

Refer to page 001 RESET of the D5BUG. The left most five digits (or field) are called line number, shown under the PAGE heading. These numbers are used to keep track of the line number in the source code that a particular statement was on.

The letter appearing next to a line number (always A in the D5BUG) stands for ASCT, meaning "absolute section". This letter has meaning only when using a relocatable program.

The next four digits are ADDR, or address. This is the actual address in memory for the particular instruction. For instance, line 9 (00009A) has F000 which is a location in the D5BUG ROM. Successive addresses are not necessarily in progressive order.

The next digits are called OPCODE (one byte) for the instruction. For line 00009A, the OPCODE is 01.

The next digits or field can be zero bytes, one byte, or two bytes. At line 00009A, there are no bytes to the right of the OPCODE, but at line 00011A, there are two bytes (E3 and FF), and at line 00013A there is one byte (00). This general field is called the OPERAND.

At line 00009A, the notation NOP requires the OPERAND to be zero bytes. At line 00011A, the notation LDX means OPCODE CE which requires the OPERAND to be two bytes which are E3 and FF. Thus, LDX is load x with E3 and FF as specified.

A special case of the OPERAND field is shown in line 00015A. The OPCODE 26 is for BNE, which is "Branch Not Equal". The value F8 is the relative offset to CLRLOP. The F005 is a reference reminder that this is the "branch to" address.

In line 00012A, the label CLRLOP is at address F005, so in line 00015A, the "branch to" address is F005. In the ROM, the F005 is not present, but the notation 26 at F00B is present, along with F8 at F00C.

At the next line, there is an F00D and CE. Thus the F005 is not a part of the code, but merely tells where to branch to.

The next field may contain a letter (A, shown in the D5BUG listing) which again is ASCT.

The next field is a label field but is not used very often. It is used as a reference reminder for the assembler.

7.7 D5BUG Listing Description (cont'd)

An asterisk (*) in the listing in the first column of any particular line of the source code, means that line is a comment. No code will be assigned by the assembler.

The mnemonic field (line 00009A has NOP, no operation), is the English equivalent of the OP CODE.

The mnemonics are all listed in the Instruction Set Summary booklet for the M6800 microprocessor.

Also in this field are assembler directives, such as in line 00001 - NAM, and OPT (option) in the next line. These do not generate any machine codes.

In line 00002, CREF and LLEN=80 stand for cross-reference and line length.

Another operand field is shown at line 00045A. The notation FOBB is the machine code operand and PUT is the source operand.

An operand can be a name, or a number as in line 00032. LDAA #1 means "load A immediate one". The # symbol means "immediate". Also in this line (00032A), F027 is the address in memory, 86 is the opcode for load A immediate, 01 is load with zero one.

In line 00038, the symbol \$ means hex. In line 00040, the % symbol stands for binary. In line 00023, 3, X specifies indexed addressing mode.

In line 00044, the notation JSR ENNMI creates the code BD F7AE, which is explained by the comment "enable NMI" in the last field to the right.

At the end of the listing (after line 1333), another listing, the cross reference, is shown.

This starts with F789, an address for the label ABORT.

The line numbers (in the previous listing) for ABORT are 1198 and 1202*. The number with the * is the line number where the label was defined, and the other number is the line where ABORT was used.

In this listing, line E442 is BKPNTN. It is referenced to ten places in the previous listing, and is defined in line 1286.

The cross reference listings (table) thus can be used to find any particular label in another listing.